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NWS EARLE
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QUALITY ASSURANCE PROJECT PLAN FOR CLASSIFICATION EXCEPTION AREA INVESTIGATION GROUNDWATER SAMPLING AT SITE 13 DEFENSE PROPERTY DISPOSAL OFFICE WITH TRANSMITTAL NWS EARLE NJ

8/1/2004

TETRA TECH

000001043

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SEP - 1 2004

PITT-08-4-070

August 30, 2004

Project Number N6710

Ms. Michele DiGeambeardino
Naval Facilities Engineering Command
EFANE (Code EV21/MD)
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Reference: CLEAN Contract No. N62467-94-D-0888
Contract Task Order No. 851

Subject: Quality Assurance Project Plan, Classification Exception Zone Investigation
Groundwater Sampling
Site 13 – Defense Property Disposal Office Yard (OU-5)
Naval Weapons Station Earle, Colts Neck, New Jersey

Dear Ms. DiGeambeardino:

Please find enclosed an internal (to Navy) draft of the Quality Assurance Project Plan (QAPP), Classification Exception Zone (CEA) Investigation Groundwater Sampling for the above-referenced site.

Copies of this internal draft have also been sent to Mr. Jim Briggs. Concurrently with your review, the document is being reviewed by a technical editor. Once you and Mr. Briggs have completed your review, the document will be revised as required and issued as a draft to the USEPA and NJDEP.

Should you have any questions, please call me at 412-921-8259.

Sincerely,

Daniel C. Witt

Daniel C. Witt, P.E.
Project Manager

DW/kf

Enclosures

c: Mr. Roger Boucher, NORTHDIV (w/o enclosure)
Mr. Jim Briggs, EFANE (1 copy)
Ms. Alicia Hartman, NWS Earle (1 copy)
Mr. Russ Turner, Tetra Tech NUS, Inc. (1 copy)
Mr. John Trepanowski, Tetra Tech NUS, Inc. (1 copy)
Project File N6710

Quality Assurance Project Plan
for
Classification Exception Area Investigation Groundwater Sampling at Site 13 – Defense Property Disposal Office (DPDO) Yard

Naval Weapons Station Earle
Colts Neck, New Jersey

Engineering Field Activity Chesapeake
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0851

August 2004

TETRA TECH NUS, INC.

080409/P

QUALITY ASSURANCE PROJECT PLAN
FOR
CLASSIFICATION EXCEPTION AREA INVESTIGATION
GROUNDWATER SAMPLING
AT
SITE 13 – DEFENSE PROPERTY DISPOSAL OFFICE (DPDO) YARD

NAVAL WEAPONS STATION EARLE
COLTS NECK, NEW JERSEY

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Engineering Field Activity Northeast
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop #82
Lester, Pennsylvania 19113-2090

Submitted by:
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600 Clark Avenue, Suite 3
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0851

AUGUST 2004

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LIST OF ACRONYMS AND ABBREVIATIONS

%R	Percent recovery
µg/L	micrograms per liter
ASTM	American Society for Testing and Materials
bgs	below ground surface
CEA	Classification Exception Area
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COC	chain of custody
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CTO	Contract Task Order
DPDO	Defense Property Disposal Office
DQO	data quality objectives
EFANE	Engineering Field Activity Northeast
EPA	Environmental Protection Agency
ESQD	explosive safety quantity distance
FOL	Field Operations Leader
FS	Feasibility Study
FTMR	Field Task Modification Request
GC	gas chromatograph
GC/MS	gas chromatograph / mass spectrometer
HASP	Health and Safety Plan
HSM	Health and Safety Manager
IC	ion chromatograph
ICP	inductively coupled plasma
IDL	instrument detection limit
IDW	investigative derived waste
IR	Installation Restoration
LCS	laboratory control sample
MS/MSD	matrix spike / matrix spike duplicate
msl	mean sea level
NFSEC	Naval Facilities Engineering Service Center
NIST	National Institute of Standards and Technology
NJAC	New Jersey Administrative Code

1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared by Tetra Tech NUS (TtNUS) on behalf of the United States Navy Engineering Field Activity Northeast and the Naval Weapons Station (NWS) Earle, Colts Neck, New Jersey, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract Number N62467-94-D-0888, Contract Task Order (CTO) 851. This QAPP includes sections that constitute the Work Plan and Sampling and Analysis Plan (WP/SAP). The QAPP and Health and Safety Plan (HASP), together constitute the project planning documents for this Investigation to support establishment of a Classification Exception Area (CEA Investigation) for groundwater as required by the Record of Decision (ROD) at the Defense Property Disposal Office (DPDO) Yard (Site 13) NWS Earle.

This QAPP presents the organization, objectives, planned activities, and specific Quality Assurance/Quality Control (QA/QC) procedures for the site investigation. Specific protocols for sampling, sample handling and storage, chain-of-custody, and laboratory and field analyses are described within this document. All QA/QC procedures are structured in accordance with applicable technical standards, the Naval Facilities Engineering Service Center (NFESC) guidance document "Navy Installation Restoration Laboratory Quality Assurance Guide (February 1996), and United States Environmental Protection Agency (USEPA) Region II and New Jersey Department of Environmental Protection (NJDEP) requirements, regulations, guidance, and technical standards.

1.2 FACILITY DESCRIPTION

NWS Earle is located in Monmouth County in east-central New Jersey (see Figure 1-1). It is situated on approximately 11,134 acres and includes a Mainside area, which is approximately 10 miles inland from the Atlantic Ocean at Sandy Hook Bay, and a Waterfront area, which includes an ammunition depot and associated piers. The Mainside and Waterfront areas are linked by a narrow tract of land that serves as a right-of-way for a government road and railroad. Site 13 is located in the Mainside area.

The main entrance to NWS Earle is located off State Route 34, and the entrance to the Waterfront area is located adjacent to State Route 36.

Land use at the Mainside area includes residences, office buildings, workshops and warehouses, recreational areas, open space, and undeveloped land. The majority of the land at the Mainside area is undeveloped and is associated with ordnance operations, production, and storage facilities; the undeveloped land is encumbered by explosive safety quantity distance (ESQD) arcs. The area around the Mainside portion of the Facility includes agricultural areas, vacant land, and low-density residential land.

1.3 SITE DESCRIPTION

This section summarizes pertinent surface features, geology, and hydrogeology information for NWS Earle and Site 13. This information was obtained from the Feasibility Study (FS) for Site 13 at NWS Earle (TtNUS, 2000). Figure 1-2 shows the Mainside area Installation Restoration (IR) program sites, including Site 13.

NWS Earle is located in the coastal lowlands of Monmouth County, New Jersey, within the Atlantic Coastal Plain Physiographic Province. The Mainside area, which includes Site 13, lies in the outer Coastal Plain, approximately 10 miles inland from the Atlantic Ocean. The Mainside area is relatively flat, with elevations ranging from approximately 100 to 300 feet above mean sea level (msl). The most significant topographic relief within the Mainside area is Hominy Hills, a northeast-southwest-trending group of low hills located near the center of NWS Earle.

Site 13 is located at least partially within ESQD arcs; therefore, future development at this site is severely restricted.

Site 13 in an area of fill material extending into a marsh near the rail classification yards (Figure 1-3). Site 13 is located in the northern end of the DPDO Yard and extends past the fence which surrounds the DPDO Yard. Activities at the site included storage of scrap metals and batteries and the burial of material, such as cars, trucks, electronic equipment, clothing/shoes, sheet metal, furniture, scrap metal, and batteries. Additionally, batteries were broken open at the site for lead recovery, and acid was drained onto the ground. Because the primary function of this site was scrap metal storage, unexploded ordnance (UXO) is not expected to be present in the fill material; however, ordinance "shapes" have been encountered at this site during previous intrusive activities. Obvious fill material is present at the ground surface at several places across the site. A partial removal of exposed debris was performed by NWS Earle public works employees in the summer of 1997.

Hydrology

The rivers and streams draining NWS Earle ultimately discharge to the Atlantic Ocean, which is located approximately 10 miles east of the Mainside area. The headwaters and drainage basins of three major Coastal Plain rivers (Swimming, Manasquan, and Shark) originate on the Mainside area. The northern half of the Mainside is in the drainage basin of the Swimming River, and tributaries include Mine Brook, Hockhockson Brook, and Pine Brook. The southwestern portion of the Mainside area drains to the Manasquan River via either Marsh Bog Brook or Mingamahone Brook. The southeastern corner of the Mainside area drains to the Shark River. Both the Swimming River and the Shark River supply reservoirs used for public water supplies.

Runoff from the site drains north to the marsh and west to a perennial drainage channel that flows to Hockhockson Brook. A fence surrounds the DPDO Yard but is not located at the edge of the landfill. The extent of fill material was not clearly defined to the east by previous investigations. The toe of the landfill extends north of the DPDO yard fence into the marsh area and is clearly defined by an abrupt decrease in elevation of several feet between the top of the landfill slope and the marsh. Based on the site topography, it is thought that the depth of waste is less than 10 feet below ground surface.

Geology

NWS Earle is situated in the Coastal Plain Physiographic Province of New Jersey. The New Jersey Coastal Plain is a seaward-dipping wedge of unconsolidated Cretaceous to Quaternary sediments deposited on a pre-Cretaceous basement-bedrock complex. The Coastal Plain sediments are primarily composed of clay, silt, sand, and gravel and were deposited in continental, coastal, and marine environments. The sediments generally strike northeast-southwest and dip to the southeast at a rate of 10 to 60 feet per mile. The approximate thickness of these sediments beneath NWS Earle is 900 feet. The pre-Cretaceous complex consists mainly of Pre-Cambrian and lower Paleozoic crystalline rocks and metamorphic schists and gneisses. The Cretaceous to Miocene Coastal Plain Formations are either exposed at the surface or subcrop in a banded pattern that roughly parallels the shoreline. The outcrop pattern is caused by the erosional truncation of the dipping sedimentary wedge. Where these formations are not exposed, they are covered by essentially flat-lying Post-Miocene surficial deposits.

Regional mapping places Site 13 within the outcrop area of the Vincentown Formation, which ranges between 10 and 130 feet in thickness in the NWS Earle area. The lithology of the sediments encountered in the on-site borings generally agrees with the published description of the Vincentown Formation. In general, the borings encountered alternating beds of yellowish-brown to brown, micaceous, silty, fine- to medium-grained sand and olive, glauconitic, silty sand and sand.

Hydrogeology

Groundwater classification areas are defined under NJDEP Water Technical Programs Groundwater Quality Standards in New Jersey Administrative Code (NJAC) 7:9-6. The Mainside area is located in the Class II-A, Groundwater Supporting Potable Water Supply, area. Class II-A includes those areas where groundwater is an existing source of potable water with conventional water supply treatment or is a potential source of potable water. In the Mainside area, in general, the deeper aquifers are used for public water supplies, and the shallower aquifers are used for domestic supplies.

Groundwater in the Vincentown aquifer beneath Site 13 occurs under unconfined conditions and is encountered at approximately 3 to 11 feet below ground surface (bgs). The direction of shallow groundwater flow in the aquifer under Site 13 is north-northwest. There does not appear to be a significant seasonal variation in groundwater flow direction. The hydraulic conductivity calculated for monitoring well MW13-04 is 2.64×10^{-5} centimeters per second (0.75 feet per day).

Nature and Extent of Contamination

The following discussion of nature and extent of contamination is excerpted from the proposed plan for Site 13 (TtNUS, 2002). Additional information can be found in the RI (B&R Environmental, 1998) and the FS (TtNUS, 2000). During the Site Inspection, six soil, three sediment, and three surface water samples were collected from Site 13. Surface water samples were analyzed for SVOCs, PCBs, pesticides, metals and cyanide. Elevated levels of several metals were present in surface water samples. No SVOCs, pesticides, or PCBs were detected in surface water. Low levels of metals, pesticides, PCBs, and SVOCs were detected in soil samples. Elevated levels of two semivolatiles were also detected in soil. Sediment samples were analyzed for SVOCs, pesticides, and PCBs. Low levels of pesticides, PCBs, and SVOCs were detected in sediments.

The Remedial Investigation (RI) at Site 13 included the installation and sampling of monitoring wells, the collection of soil, surface water, and sediment samples, and the excavation of test pits to observe wastes and sample subsurface soil. A wide variety of metals and volatile, semivolatile, and pesticide compounds were detected in Site 13 groundwater. PCBs, metals, semivolatiles, and pesticides were found in sediment, and limited metals were detected in surface water.

During 2003, a pre-design investigation was completed at Site 13 to better define the limit of sediment contamination at the toe of the landfill. Samples were analyzed for PCBs and TAL metals. The sampling showed an area of contamination that extended approximately 120 feet out from the toe of the landfill.

Site Status

The Proposed Plan for Site 13 was issued in December 2002 (TtNUS, 2002) and presented the preferred remedial alternative for Site 13 and summarized the information that led to the selection of the preferred alternative. The preferred alternative includes capping the landfill portion of the site with a low-permeability cover system, institutional controls, and long-term monitoring. Also indicated in the Proposed Plan are two areas of possible excavation located outside the landfill limit. These areas are associated with sediment contamination were the focus of the pre-design investigation. The remedy also indicates that a CEA will be established for Site 13 groundwater. The focus of this investigation is to collect data that will be used to support the establishment of a CEA. The Record of Decision (ROD) for this site is currently being prepared. The investigation outlined in the QAPP is being performed as part of pre-design activities for Site 13. It is anticipated that the results of this investigation will be presented in remedial design documents.

1.4 REPORT CONTENTS

Section 1.0 of this QAPP is the introduction and site background. Section 2.0 details the scope of work to be conducted for this investigation and the use of the data to be collected. Section 3.0 discusses the project organization including personnel and entities involved with this project. Section 4.0 discusses sampling procedures and field activities. Sections 5.0 through 15.0 detail the QA/QC requirements for the data collection, analysis, and validation. Appendix A contains the project specific HASP. Appendix B contains field forms and Appendix C contains standard operating procedures (SOPs).

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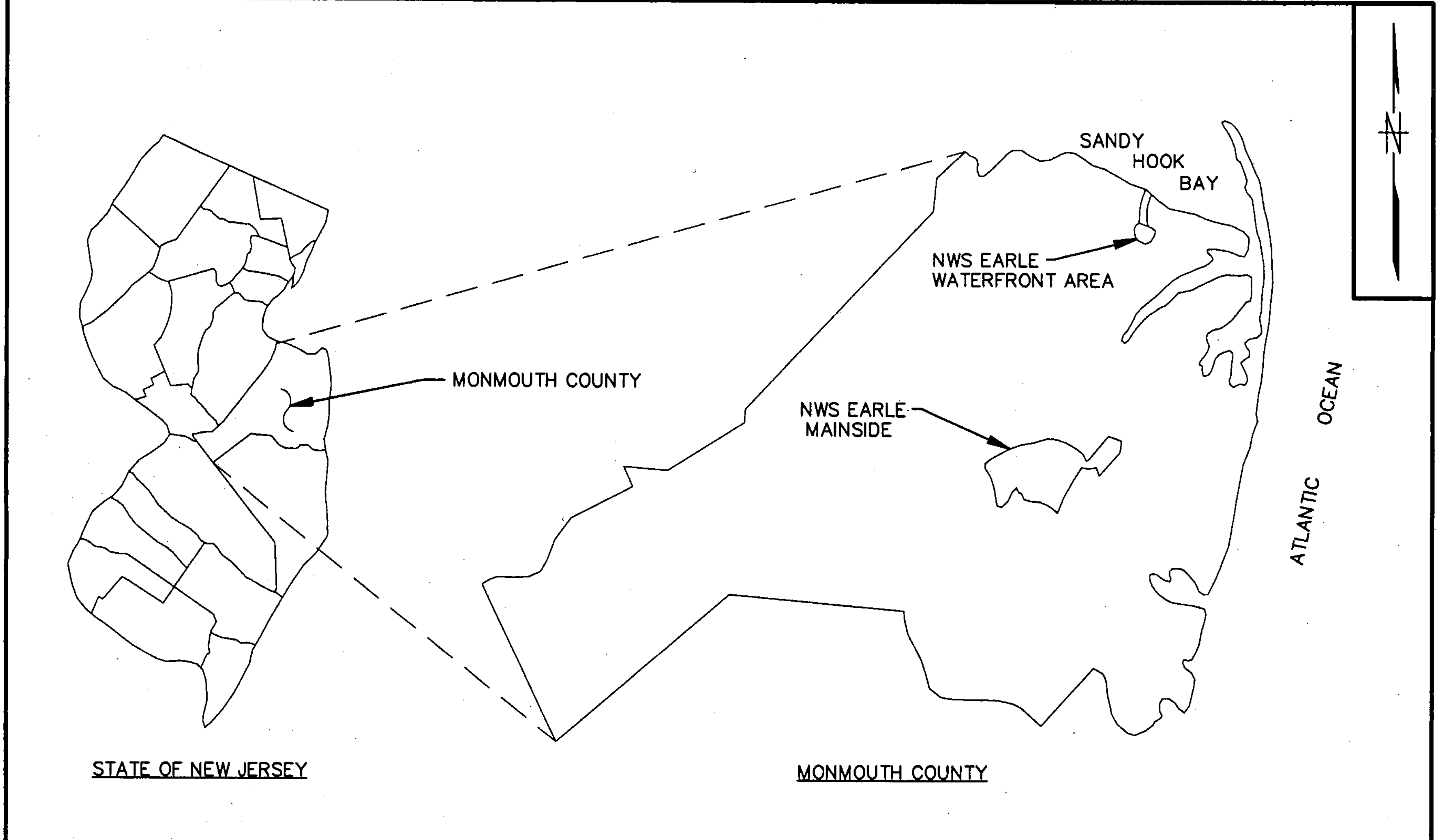

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COST/SCHED-AREA		APPROVED BY — DATE	
SCALE NOT TO SCALE		DRAWING NO. FIGURE 1-1	REV. 0

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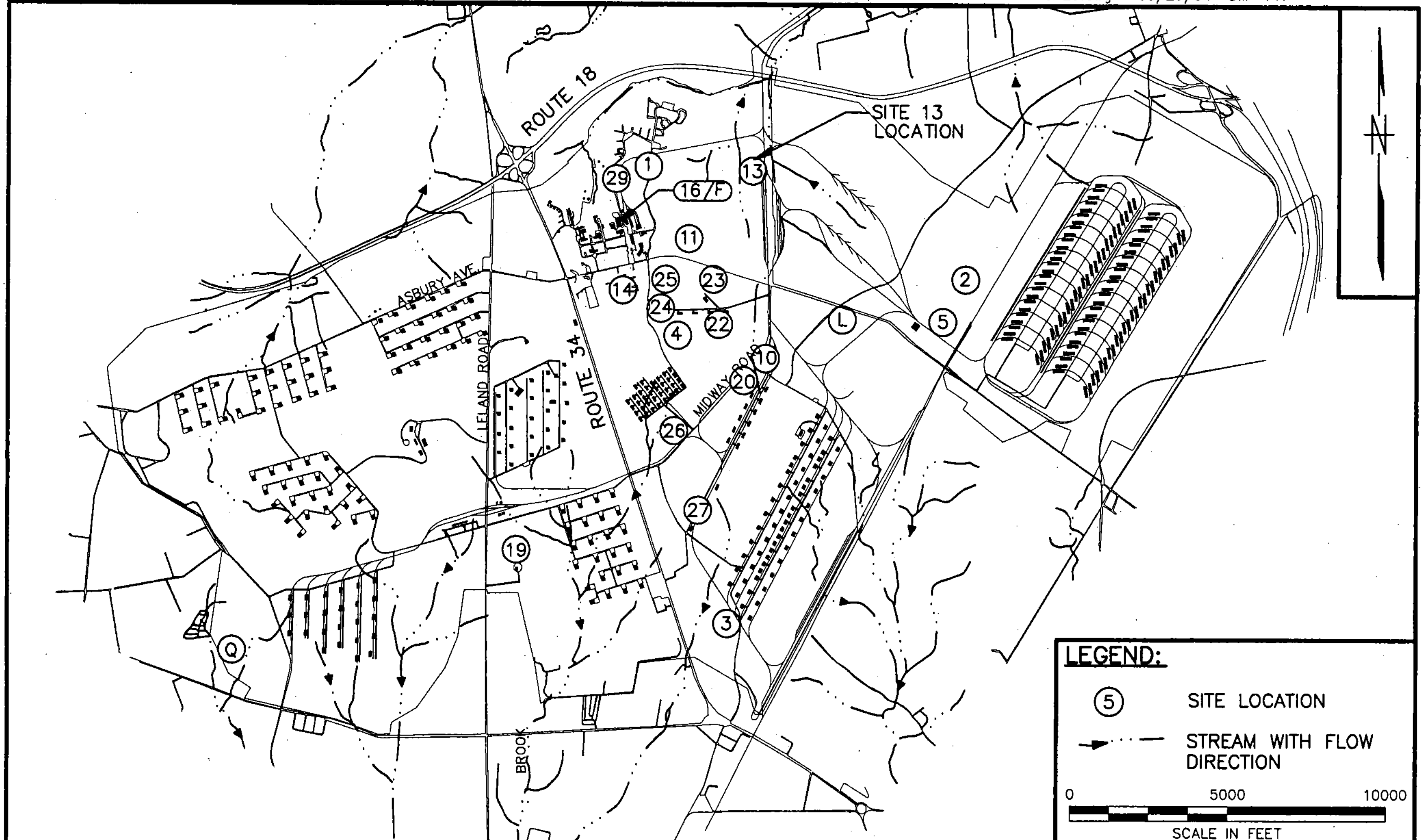

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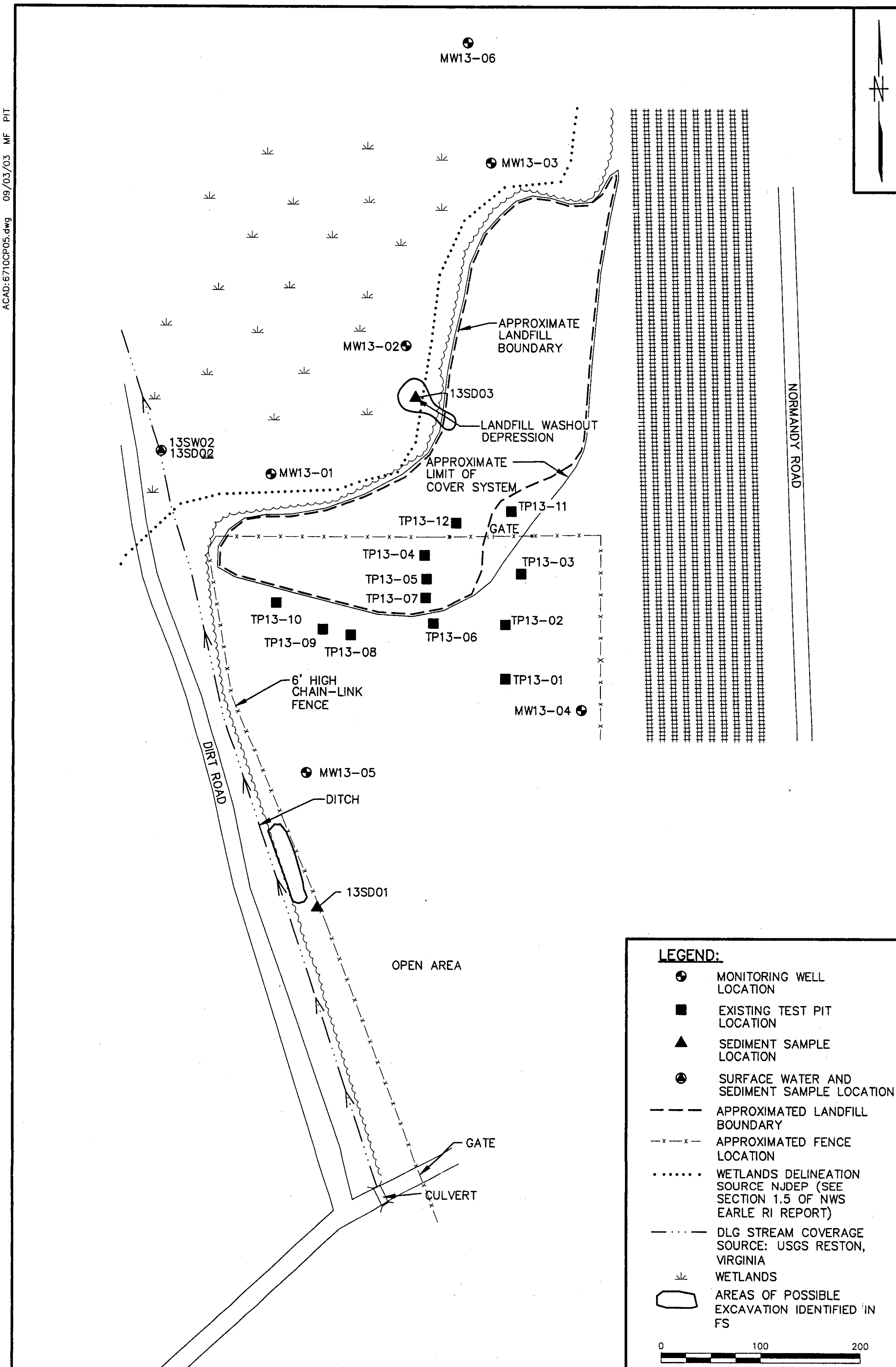

DRAWN BY DM / DATE 8/26/04	Tetra Tech NUS, Inc.	CONTRACT NO. 6710	OWNER NO. 0851
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COST/SCHED-AREA		APPROVED BY	DATE
SCALE AS NOTED		DRAWING NO. FIGURE 1-3	REV. 0

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2.0 SCOPE OF WORK

2.1 PROJECT OBJECTIVES

The purpose of this CEA Investigation is the collection of groundwater data to support the establishment of a CEA for Site 13. The ROD indicates that a CEA will be established to provide the state with official notice that the constituent standards will not be met for a specified duration and to ensure that the use of groundwater in the affected area is prohibited. The most recent groundwater sampling at Site 13 occurred during the RI and RI addendum investigations. The data for these investigations were collected in 1995 and 1996. The Groundwater Exception Area Guidance Document (NJDEP, 1998) indicates that additional or confirmatory well sampling is required if a significant portion of the data is more than 2 years old. Because the existing groundwater data is significantly older than 2 years old, new groundwater data needs to be collected to support the CEA. To establish the CEA, two characteristics of the plume must be determined. First, the amount of time that the contaminant concentration will take to reach the New Jersey Groundwater Quality Standards (NJ GWQS) goals must be determined. Second, the distance that the contamination will migrate must be established (NJDEP 1998). In addition, new monitoring wells at the down gradient edge of the groundwater plume will be needed for long term monitoring of the Site.

Many of the previous groundwater samples were collected using direct push technology (DPT) so that permanent wells were not installed. Consequently these locations can not be resampled without installing a new well or using DPT again. Therefore new monitoring points need to be established. Since the groundwater at Site 13 has not been sampled for approximately seven years the location of the down gradient edge of the plume must be verified.

The objective of the CEA investigation is to collect groundwater data which will determine the down gradient edge of the groundwater plume and will provide current groundwater data on which predictions of the plume migration and longevity can be made. The monitoring points may also be used for long-term monitoring of the Site.

2.2 GROUNDWATER CONTAMINANTS OF CONCERN AND CRITERIA

The ten groundwater contaminants of concern (COCs) were established in the FS report (TtNUS 2000). The COCs include: Antimony, arsenic, cadmium, chromium (total), iron, lead, 1,2-dichloroethene, trichloroethene, tetratchloroethene, and vinyl chloride. The FS proposed that NJ GWQS be used as preliminary remediation goals (PRGs) for all of the COCs except for iron. Background was cited (7690 mg/L) as the PRG for iron. The NJ GWQS and the background value for iron will be used in calculating the extent and longevity of the plume.

2.3 INVESTIGATION AREA

The investigation area will focus on resampling the existing monitoring wells and to collect additional groundwater data down gradient of the existing monitoring wells where it is expected that the edge of the plume lies.

Down gradient of the existing monitoring wells, new wells will be drilled in a stepwise fashion. The shortly after installation of the wells, the wells will be sampled with a quick turn analysis. That data will then be used to determine if additional wells will be required to define the edge of the plume. If it is determined that that newly installed wells are not needed for long term monitoring the wells will be abandoned. It is anticipated that 10 shallow monitoring wells will be drilled and that 6 wells will be kept for future monitoring.

2.4 DECISION RULE

Groundwater samples will be collected from the 6 existing wells located at the site concurrent with the installation of the 10 additional temporary/permanent wells. All groundwater samples will be submitted for expedited laboratory analyses for select VOAs and metals. Each of the newly installed wells will also be sampled and analyzed for the same constituents, immediately following installation and development of each well. In addition, a round of water level measurements will be taken in all existing wells and a portion of the newly installed wells and staff gauges approximately halfway through the investigation, to develop a preliminary potentiometric surface map with groundwater flow directions for the area of interest. The potentiometric surface data will be evaluated in conjunction with the expedited laboratory analyses results to help determine the remaining monitoring well locations, and to determine which wells will ultimately be completed as permanent wells. The analytical data will be evaluated for contaminant type, magnitude, frequency, and location; and will be compared to the 1995 analytical database to evaluate plume characteristics over time. The overall intent of the investigation will be to monitor groundwater upgradient of the impacted areas, within the impacted areas, immediately downgradient of the impacted areas along the plume fringe, and further downgradient in unimpacted areas where the plume has yet to travel. Which this in mind, it is anticipated that the groundwater analytical results will vary from non detections, upwards through detections exceeding regulatory criteria, and approaching or perhaps exceeding those concentrations found during the 1995 investigation.

2.5 SAMPLING DESIGN AND ANALYSIS

The sampling design is intended to initially establish baseline conditions by sampling all the existing wells and comparing the newly acquired data to the 1995 database, to evaluate plume characteristics over time. Secondly, the sampling design is intended to obtain real time data as the investigation progresses, to determine optimum well locations and to develop the framework for long term groundwater monitoring of the site.

It is anticipated that groundwater contamination still exists in groundwater at concentrations that are similar to that found during the 1995 investigation, and that the plume has most likely migrated further downgradient. However, it is also likely that the plume has naturally attenuated and degraded over time, but the extent that these mechanisms exist, and the distance that the plume has traveled; is not known.

The proposed monitoring well network is designed in a series of three arcs, or lines; starting along the fringe of the plume as defined during the 1995 investigation; and progressing in a downgradient direction parallel to the groundwater flow direction. The density and number of wells in each arc decreases in a downgradient direction as more data is collected; with the intent of focusing the effort along the plume axis, once defined. The network is intended to be capable of modification as necessary to fully evaluate the effects of a migrating plume, if evident.

2.6 PROJECT SCHEDULE

The groundwater samples will be as soon as possible following approval of this work plan. Allowing time for regulatory and Navy review and final submittal of this document, it is anticipated that the sediment groundwater at Site 13 will occur at the beginning of November 2004 and will take one 10-day shift to complete. The lab analyses will then be completed on a 24-hour turnaround.

2.7 PROJECT TARGET PARAMETERS AND INTENDED DATA USES

The project target parameters include both primary constituents which are reflective of the source products found in groundwater at the site, as well as those secondary parameters which will provide useful data to evaluate those naturally occurring processes that affect the concentration of constituents in groundwater at the site.

The primary constituents of concern groundwater are select volatile organic compounds and metals. The volatile organic compounds consist of chlorinated solvent compounds (namely tetrachloroethene, trichloroethene, 1,2-dichloroethene, and vinyl chloride), and those compounds appear to be found in parent and daughter relationships, which could indicate natural attenuation. The inorganic compounds are antimony, arsenic, cadmium, chromium, iron, and lead. Analyses of these primary constituents are essential to the overall evaluation of the groundwater at the site. All existing and newly installed wells will be analyzed for select VOAs and metals.

Those secondary parameters of interest are associated with evaluating whether natural attenuation processes exist at the site, which could effective alter the organic contaminant concentrations at the site. Biodegradation of chlorinated contaminants in groundwater is most effective (in the source and near the source) under anaerobic or reducing conditions. Several geochemical parameters will be analyzed in select groundwater samples which, when evaluated in conjunction with the primary organic constituents and their parent/daughter relationships; will be used to formulate several lines of biodegradation evidence at the site.

Dissolved oxygen analyses will be used to determine whether anerobic conditions exist at the site, and is also a primary electron acceptor. Nitrate, nitrite, sulfate, and manganese are anaerobic electron acceptors, and sulfide is a common product of sulfate reduction. Chloride is the ultimate daughter product of reductive dechlorination. Ferrous iron is also a product of iron reduction. The dissolved gases are daughter products of reductive dechlorination and alkalinity is used to determine buffering capacity.

Only select monitoring wells will be analyzed for monitored natural attenuation parameters. One well, 13MW05 will be used to monitor conditions upgradient of the source. Well 13MW02 will be used to monitor groundwater concentrations in the source area. Well 13MW09 will be used to monitor groundwater concentrations along the downgradient fringe of the plume, assuming contaminated groundwater has migrated downgradient this distance. Wells 13MW13 and wells 13MW16 will monitor groundwater concentrations further downgradient of the plume, and it is anticipated that at least one of these wells will contain groundwater concentrations below regulatory standards.

TABLE 2-1

SUMMARY OF PROPOSED SAMPLING
SITE 13
NWS EARLE
COLTS NECK, NEW JERSEY

Sample Identification	Analyses		
	Select VOA	Select Metals	MNA (3)
SITE 13 GROUNDWATER SAMPLES			
13GW0102	X	X	
13GW0202	X	X	X
13GW0302	X	X	
13GW0402	X	X	
13GW0502	X	X	X
13GW0602	X	X	
13GW0701	X	X	
13GW0801	X	X	
13GW0901	X	X	X
13GW1001	X	X	
13GW1101	X	X	
13GW1201	X	X	
13GW1301	X	X	X
13GW1401	X	X	
13GW1501	X	X	
13GW1601	X	X	X
QUALITY CONTROL SAMPLES			
RB090804 (1)	X	X	
FD090404 (2)	X	X	
FD091204 (2)	X	X	

1 The 6-digit number represents the date on which the rinsate blank was collected (i.e."090804" refers to September 8, 2004. Only one rinsate blank will be required of the bladder pump during the entire field event.

2 The "090804" indicates the date on which the duplicate sample was collected. The sample/duplicate pair will be recorded on the sample logsheet. Duplicate samples are to be collected at a rate of 1 for every 10 environmental samples collected.

3 Includes Chloride, dissolved gases (Hydrogen, Ethane, Ethene, Methane), Sulfate, Sulfide, Nitrate, Nitrite, Ferrous Iron, Dissolved Oxygen, and Alkalinity. The actual wells to be analyzed for MNA may be modified based on initial receipt of expedited analytical results.

Note: A Matrix Spike / Matrix Spike Duplicate Sample (MS/MSD) will be collected at a rate of 1 for every 20 environmental samples. The MS/MSD sample consists of triple volume of the enviromnmental sample. The MS/MSD sample will be determined by the field sampler and will be noted on the chain of custody and sample logsheet.

TABLE 2-2

ANALYTICAL DETECTION LIMITS - SELECT VOCs
NWS EARLE, COLTS NECK, NEW JERSEY

Select VOC Parameter	RQL[1] for Aqueous Samples (µg/L)	Modified Calibration Levels[2] for Aqueous Samples (µg/L)
cis-1,2-Dichloroethene	35[3]	0.5
trans-1,2-Dichloroethene	35[3]	0.5
Trichloroethene	1.0	0.5
Tetrachloroethene	1.0	0.5
Vinyl chloride	2.0	0.5

1 RQL - Required Quantitation Limit.

2 CLP OLM04.3 Modified Quantitation Limits are available under the Flexibility Clause.

3 RQLs were derived from New Jersey Groundwater Quality Standard for total-1,2-dichloroethene (70 µg/L).

TABLE 2-2

ANALYTICAL DETECTION LIMITS - SELECT METALS
NWS EARLE, COLTS NECK, NEW JERSEY

Parameter	RDL[1] Aqueous Samples (μg/L)
Antimony	20
Arsenic	8.0
Cadmium	4.0
Chromium (total)	100
Iron	7690
Lead	10
Manganese	15

1 RDL - Required Detection Limit as based on New Jersey Ground Water Quality Standards except for iron which was the site background concentration and manganese which is the CLP CRQL.

TABLE 2-2

ANALYTICAL DETECTION LIMITS – DISSOLVED GASES
NWS EARLE, COLTS NECK, NEW JERSEY

Parameter	Detection Limit Aqueous Samples (μg/L)
Ethane	1
Ethene	1
Methane	1
Hydrogen	1

TABLE 2-2

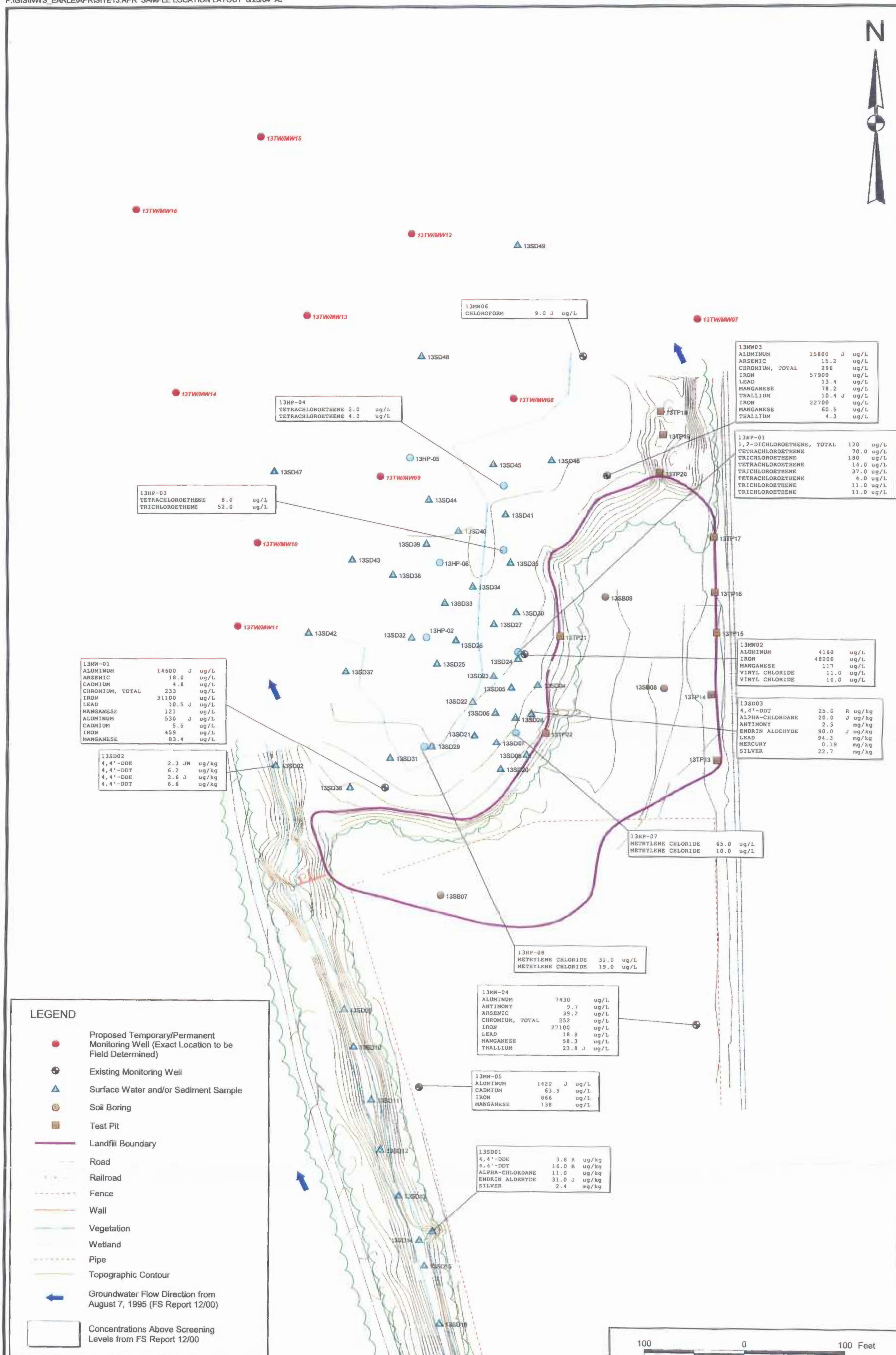
ANALYTICAL DETECTION LIMITS – MISCELLANEOUS ANALYSES
NWS EARLE, COLTS NECK, NEW JERSEY

Parameter	Estimated Detection Limit[1] (mg/L)
Dissolved Oxygen	0.025
Chloride	MDL
Nitrate	0.01
Nitrite	0.005
Sulfate	4.9
Sulfide	0.1
Ferrous Iron	0.2
Alkalinity	10

1 Estimated Detection Limits are taken from the appropriate test kit.

MDL - Method Detection Limit: The laboratory will report to the method detection limit for chloride, but no limits are listed because MDLs vary between laboratories and over time. Additionally, chloride is being analyzed for natural attenuation purposes only.

P:\GIS\NWS_EARLE\APR\SITE13.APR SAMPLE LOCATION LAYOUT 8/23/04 AJ



DRAWN BY A. JANOCHA	DATE 8/13/04	Tetra Tech NUS, Inc.	CONTRACT NUMBER N6710 / OWNER NUMBER
CHECKED BY M. COCHRAN	DATE 8/23/04	SAMPLE LOCATIONS SITE 13 - DRMO YARD NWS EARLE EARLE, NEW JERSEY	APPROVED BY / DATE
COST/SCHEDULE-AREA			APPROVED BY / DATE
SCALE AS NOTED			DRAWING NO. FIGURE 2 - 1 / REV 0

3.0 PROJECT ORGANIZATION

This section presents project management and organization information for Site 13 Classification Exception Area (CEA) Investigation sampling and analysis activities. The project organization chart for the Navy/TtNUS team is provided in Figure 3-1. The various QA and management responsibilities of the Navy and key TtNUS personnel are defined in the following paragraphs.

3.1 NAVY REMEDIAL PROJECT MANAGER

The Navy Remedial Project Manager (RPM) is responsible for overall QA of the project. The Navy RPM has the responsibility for the following specific activities:

- Implementing the remedial action in accordance with the ROD.
- Serving as lead contact person with the regulatory agencies and regulatory oversight contractor, if applicable.
- Initiating and chair meetings.
- Facilitating resolution of issues during the planning and implementation stages.
- Assuring adequate resources are provided to complete activities in accordance with the approved plans, on schedule, and within budget.
- Assuring compliance with QA policies and procedures.

The Navy RPM for NWS Earle is Ms. Michele DiGeambeardino.

3.2 TtNUS CLEAN PROGRAM MANAGER

The TtNUS Navy EFANE CLEAN Program Manager provides operations, technical, and administrative leadership and oversees and supports quality policies. The TtNUS Program Manager is responsible for the execution of all contractual obligations. He serves as the primary program point of contact for the client and provides an interface between the Navy and the project staff. The TtNUS Program Manager, Mr. John Trepanowski, may delegate authority to the Deputy Program Manager, Mr. Garth Glenn, P.E.

3.3 TtNUS PROJECT MANAGER

The TtNUS Project Manager (PM) is responsible for project performance, budget, and schedule and for ensuring the availability of necessary personnel, equipment, subcontractors, and services. The TtNUS PM will direct the development of the field program, the evaluation of findings, the determination of conclusions and recommendations, and the preparation of the technical report. The TtNUS PM is selected based upon technical experience, project needs, and previous experience. Additional responsibilities include:

- Ensuring timely resolution of project-related technical, quality, safety, or waste management issues.
- Functioning as primary interface with the Navy RPM and NWS Site Manager, field and office personnel, and subcontractor points-of-contact.
- Monitoring and evaluating subcontractor laboratory performance.
- Coordinating and overseeing work performed by field and office technical staff (including data validation, statistical evaluations, and report preparation).
- Coordinating and overseeing maintenance of all project records.
- Coordinating and overseeing review of project deliverables.
- Preparing and issuing final deliverables to the Navy.
- Approving the implementation of corrective action.

The TtNUS PM is Mr. Daniel Witt, P.E.

3.4 TtNUS HEALTH AND SAFETY MANAGER

The TtNUS Health and Safety Manager (HSM) is responsible for the following:

- Overseeing the development and review of the Site Security and HASP
- Implementing the Site Security and HASP
- Assigning the Site Safety Officer (SSO) and supervising his/her performance
- Conducting Health and Safety audits
- Preparing Health and Safety reports for management

The TtNUS HSM is Mr. Matthew Soltis.

3.5 QUALITY ASSURANCE

This section identifies the QA responsibilities for sediment sampling and analysis activities. Responsibilities of TtNUS and the analytical laboratories are discussed.

3.5.1 TtNUS Quality Assurance Manager

The TtNUS Quality Assurance Manager (QAM) is responsible for overall QA for the project and reports directly to the TtNUS Program Manager. The QAM has the responsibility for the following specific activities:

- Developing, maintaining, and monitoring QA policies and procedures.
- Providing training to TtNUS staff in QA/QC policies and procedures.
- Conducting systems and performance audits to monitor compliance with environmental regulations, contractual requirements, QAPP requirements, and corporate policies and procedures.
- Auditing project records.
- Monitoring subcontractor quality controls and records.
- Assisting in the development of corrective action plans,
- Ensuring correction of nonconformances reported in internal or external audits.
- Overseeing the implementation of the QAPP.
- Overseeing and reviewing the development and revision of the QAPP.
- Overseeing the responsibilities of the TtNUS Site QA/QC Advisor.
- Preparing QA reports for management.

The TtNUS QAM is Ms. Kelly Carper.

3.6 LABORATORY RESPONSIBILITIES

The subcontracted laboratory is responsible for analyzing all samples in accordance with the analytical methods and additional requirements specified in this QAPP. It will also be the analytical laboratory's responsibility to properly dispose of unused sample aliquots. Responsibilities of key laboratory personnel are outlined in the following paragraphs.

Laboratory Project Manager

The Laboratory Project Manager, who reports directly to the TtNUS PM, will:

- Ensuring that method- and project-specific requirements are properly communicated and understood by laboratory personnel.
- Ensuring that all laboratory resources are available on an as-required basis.
- Monitoring analytical and project QA requirements.
- Reviewing data packages for completeness, clarity and compliance with project requirements.
- Informing the TtNUS PM of project status and any sample receipt or analytical problems.

Laboratory Director

Responsibilities of the Laboratory Director include the following:

- Supporting the QA program within the laboratory
- Providing management overview of both production- and quality-related laboratory activities
- Maintaining adequate staffing to meet project analytical and quality objectives
- Approving all laboratory SOPs and QA documents
- Supervising in-house COC documentation
- Overseeing the preparation of and approving final analytical reports prior to submittal to TtNUS

Laboratory Quality Assurance Officer

The Laboratory QA Officer (QAO) has the overall responsibility for data after it leaves the laboratory. The Laboratory QAO will be independent of the laboratory but will communicate data issues through the Laboratory Project Manager. In addition, the QAO will:

- Overseeing laboratory QA
- Overseeing QA/QC documentation
- Conducting detailed data reviews
- Determining whether to implement laboratory corrective actions
- Defining appropriate laboratory QA procedures
- Preparing laboratory SOPs

Independent QA will be provided by the laboratory project manager and QAO prior to release of all data to TtNUS.

Laboratory Sample Custodian

The Laboratory Sample Custodian will report to the Laboratory Director. Responsibilities of the Laboratory Sample Custodian include the following:

- Receiving and inspecting the incoming sample containers.
- Recording the condition of the incoming sample containers.
- Signing appropriate documents.
- Verifying COCs.
- Notifying Laboratory Project Manager and Laboratory Director of sample receipt and inspection.
- Assigning a unique identification number and customer number and entering each into the sample receiving log.
- With the help of the laboratory manager, initiating transfer of the samples to appropriate lab sections.
- Controlling and monitoring access/storage of samples and extracts.

Laboratory Technical Staff

The laboratory technical staff will be responsible for sample analysis and identification of corrective actions. The staff will report directly to the Laboratory Director.

3.7 POST RECORD OF DECISION INVESTIGATION ACTIVITIES

TtNUS will be responsible for all field activities related to sediment sampling and analysis activities. The TtNUS field team will be organized according to the activities planned. Field team members will be selected based on the type and extent of effort required. All team members will be appropriately skilled and trained for the tasks they are assigned to perform. The team will consist of a combination of the following personnel:

- Field Operations Leader (FOL)
- Site QA/QC Advisor
- SSO
- Field technical staff

3.7.1 Field Operations Leader

The FOL is responsible for coordinating all on-site personnel and for providing technical assistance when required. The FOL, or designee, will coordinate and lead all sampling activities and will ensure the availability and maintenance of all sampling materials/equipment. The FOL is responsible for the completion of all sampling, field, and COC documentation will assume custody of samples and assure the proper handling and shipping of samples. The FOL is a highly experienced environmental professional who will report directly to the TtNUS PM. Specific FOL responsibilities include the following:

- Functioning as communications link between field staff members, the Site QA/QC Advisor, SSO, the NWS Site Manager and the TtNUS PM.

- Overseeing the mobilization and demobilization of all field equipment and subcontractors.

- Coordinating and managing the field technical staff.

- Adhering to the work schedules provided by the PM.

- Bearing responsibility for maintenance of the site logbook, field logbook, and field record-keeping.

- Initiating Field Task Modification Requests (FTMRs) when necessary.

- Identifying and resolving problems in the field; resolving difficulties in consultation with the NWS Site Manager; implementing and documenting corrective action procedures and providing communication between the field team and upper management.

3.7.2 Site Quality Assurance/Quality Control (QA/QC) Advisor

The FOL (or designee) will act as the Site QA/QC Advisor, who is responsible for ensuring adherence to all QA/QC guidelines as defined in the QAPP. Strict adherence to these procedures is critical to the collection of acceptable and representative data. The following is a summary of the Site QA/QC Advisor's responsibilities:

- Ensuring that field duplicates and field QC blanks are collected with the proper frequency.

- Ensuring that additional volumes of sample are supplied to the analytical laboratory with the proper frequency to accommodate laboratory QA/QC analyses.

- Ensuring that measuring and test equipment are calibrated, used, and maintained in accordance with applicable procedures.

- Acting as liaison between site personnel, laboratory personnel, and the TtNUS QAM.

- Managing bottleware shipments and overseeing field sample preservation.

3.7.3 Site Safety Officer

The FOL (or designee) will also serve as the SSO. The duties of the SSO are detailed in the HASP. The SSO has stop-work authority, which can be executed upon the determination of an imminent safety hazard.

3.7.4 Field Technical Staff

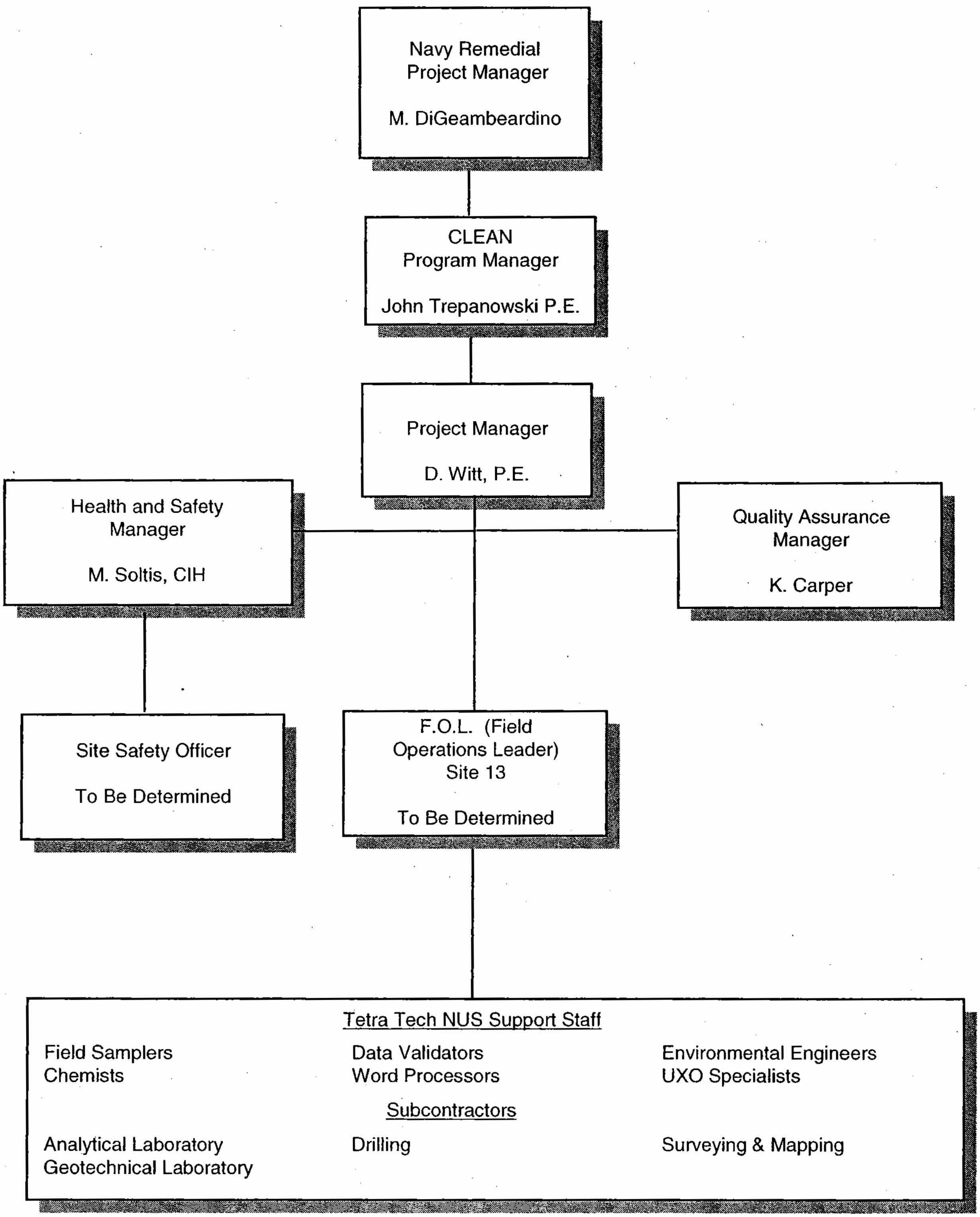
The field technical staff for this project will be drawn from TtNUS's pool of qualified personnel. All of the designated field team members will be experienced professionals who possess the degree of specialization and technical competence required to effectively and efficiently perform the required work. The field staff is responsible for complying with field-related requirements as presented in the QAPP.

3.8 SPECIAL TRAINING REQUIREMENTS AND CERTIFICATIONS

All field personnel will have appropriate training to conduct the field activities to which they are assigned. Additionally, each site worker will be required to have completed a 40-hour course in Health and Safety Training as described under Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1610.120(b)(4) as well as the requirements/training and certifications outlined in the project-specific HASP.

FIGURE 3-1

PROJECT ORGANIZATION CHART
SITE 13
NWS EARLE, COLTS NECK, NEW JERSEY



4.0 FIELD ACTIVITIES AND PROCEDURES

The field activities will include the following tasks:

- Mobilization/demobilization
- Temporary / permanent monitoring well installations
- Groundwater Sampling
- Water level measurements
- Investigative Derived Waste Handling
- Sample handling

The sample identification numbers and required analyses for the samples proposed at Site 13 are provided in Table 2-1. A summary of the field and laboratory analytical methods and bottleware, preservation, and holding time requirements is provided in Table 4-1. Field activities will be performed in accordance with TtNUS standard operating procedures, which are located in Appendix B. Field Forms are located in Appendix C.

4.1 MOBILIZATION/DEMOBILIZATION

TtNUS will prepare specifications and obtain subcontractors for the monitoring well drilling, surveying, and laboratory analyses. All field team members will review this QAPP and the project HASP prior to the initiation of the field activities. The project-specific HASP is provided in Appendix A. In addition, a field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

4.2 TEMPORARY/PERMANENT MONITORING WELL INSTALLATIONS

A total of 10 monitoring wells will be installed at the approximate locations shown on Figure 2-1. The wells will be installed into the shallow groundwater and will be terminated at an approximately depth of 15 feet beneath the ground surface. The wells will be initially installed as temporary wells, followed by well development, purging, and groundwater sampling for expedited analyses. The results of the expedited analyses will be used to make field determinations regarding subsequent well locations, and will be used to determine which temporary wells should be completed as permanent wells, to support long term monitoring. Those temporary monitoring wells not completed as permanent wells will be abandoned at the completion of the field activities.

Both temporary and permanent monitoring wells will be drilled and installed in a similar manner, however the temporary wells will not have protective casings and concrete pads installed until a determination is made to either complete the well as a permanent installation or abandon the well. Temporary wells determined to be used as permanent installations will be completed by installing the protective casing and concrete pad.

The well borings will be drilled using Hollow Stem Auger drilling techniques to the desired depth. Split barrel sampling will be performed in accordance with ASTM methods at a frequency as determined by the field geologist. Drill cuttings will be spread at the drill locations. Once the desired depth is reached, the well will be installed. NSF approved, PVC schedule 40 well screen with a slot size of .010 inches and a length of 10 feet will be screwed onto NSF approved, PVC schedule 40 riser pipe; and lowered into the boring. A uniform sand pack will be placed around the well screen to a depth of 2 feet above the top of the well screen. A minimum two foot thick, bentonite pellet seal will be installed above the sand pack. The top of the riser pipe will be capped with an expandable (J-type) cap with keyed alike lock. The remainder of the boring (approximately 1 foot) will remain open until a determination is made based on analytical results regarding whether to complete the wells as permanent installations or to abandon the wells. All well installation materials will be installed through the center of the augers as the augers are withdrawn from the boring, to ensure adequate installation of well construction materials without caving.

Temporary wells determined to remain as permanent installations will be completed by installing a 4 foot by 4 foot by 6 inch thick concrete pad with a steel protective casing and locking cap around each riser pipe. Concrete will be allowed to fill the remainder of the well annulus surrounding the riser pipe.

Temporary wells determined not to be essential for long term monitoring purposes will be abandoned at the completion of the field activity. The riser pipe and well screen will be pulled from the well boring and the void space will be backfilled with bentonite pellets to the ground surface. The temporary well location will be marked with a wooden stake for future surveying.

All wells will be developed a minimum of 24 hours after installation with a surge block, submersible pump, bailer, and / or peristaltic pump. Measurements of temperature, pH, conductivity, and turbidity will be monitored during development. Development will continue until the discharge water is visibly clear but no more than one hour per well. The development water will be discharged onto the ground surface at each well location.

4.3 GROUNDWATER SAMPLING

Groundwater sampling will be performed in all the 6 existing wells and the newly installed 10 temporary wells immediately after each well is developed. The groundwater samples will be submitted for expedited analyses and the results will be used to determined which wells will be used to guide the remainder of the investigation regarding additional well placement, and will be used to determine which wells will be completed as permanent installations. The wells will be sampled using downhole bladder pumps. The existing 6 monitoring wells presently have dedicated downhole bladder pumps and will be sampled initially at the beginning of the project, whereas the newly installed wells will be sampled with a bladder pump and replaceable bladder, the pump housing will be decontaminated between samples.

The wells will be purged using the low flow purging sampling technique and flow - through cell connected to the water quality meter. Measurements of pumping rate, water level drawdown, pH, ORP, conductivity, temperature, turbidity, and dissolved oxygen will be collected every 10 minutes during purging. The pumping rate will be maintained during purging to ensure that no more than 0.3 feet of drawdown is achieved during purging. Purging will be initiated at a flow rate of 100ml/min and will be adjusted as necessary but will not exceed 400 ml/min. Purging will continue until at least one casing volume of water is removed and stabilization is reached as determined based on the following criteria for 3 consecutive measurements:

- pH ± 0.2 standard units
- Specific conductance ± 10%
- Temperature ± 10%
- Turbidity less than 10 NTUs
- Dissolved oxygen ± 10%

Purging will continue for up to 4 hours, if necessary, until stabilization is reached. If stabilization is not reached after 4 hours, then the groundwater sample will be collected and the information recorded on the sample logsheet. Wells with turbidity measurements in excess of 10 NTU's will be sampled for both filtered and unfiltered metals analyses.

Wells that are purged dry will be allowed to recover twice during purging, then will be allowed to recover once again prior to collecting the sample. Groundwater sampling will be performed within 24 hours after the start of purging. Purge water will be discharged onto the ground surface at each well location.

4.4 WATER LEVEL MEASUREMENTS

Water level measurements will be collected in all of the existing monitoring wells and in the initially installed new temporary wells during the early stages of the investigation. The information will be used to prepare a potentiometric surface contour map to aid in the placement of subsequent wells as the investigation progresses. The newly installed well riser pipes will be field surveyed for elevation in relation to the existing wells to determine potentiometric surface elevations. Temporary staff gauges will also be installed as necessary (using existing features such as bridge abutments, culvert pipes, or wooden stakes) in surface water bodies to determine the groundwater/surface water interrelationship.

One comprehensive round of groundwater level measurements will also be collected in all the existing and new wells and staff gauges at the site. The measurements will be taken using an electronic water level indicator.

4.5 AQUIFER TESTING

Up to 6 selected monitoring wells will be tested to determine aquifer parameters. The monitoring wells will be slug tested using both rising and falling head tests. A hydrologic monitor connected to a pressure sensitive transducer will be used to record the change in water level with respect to time, and a solid slug will be used to displace a known volume of water in the well.

4.6 SURVEYING

All newly installed monitoring wells and staff gauges will be surveyed by a licensed surveyor at the completion of the project. The points will surveyed for both vertical and horizontal control before the temporary wells are abandoned.

4.7 DECONTAMINATION

Items requiring decontamination include sampling and monitoring equipment as well as the downhole drilling equipment. The sampling and monitoring equipment including the bladder pump, water level indicator, transducer probe, solid slug, and water quality probe will be decontaminated using the following procedure:

- Liquinox/water wash
- Tap water rinse
- Deionized water rinse (bladder pump only)

An isopropanol water rinse will follow the tap water rinse in the event that an oily residue is present.

The downhole drilling and sampling tools will be decontaminated with a pressurized hot water water wash.

The decontamination activities will be performed on the landfill area and the decontamination fluids will be discharged onto the ground surface.

4.8 INVESTIGATIVE DERIVED WASTE HANDLING

Investigative Derived Waste (IDW) that will be accumulated during the field investigation will include:

- Disposable sampling equipment
- Used personal protection equipment (PPE)
- General refuse
- Drill Cuttings
- Purge and development water
- Decontamination Fluids

Disposable sampling equipment and used PPE will be decontaminated with a Liquinox / water wash and discarded, with general refuse; in solid waste dumpsters at the facility. Drill cuttings will be spread out at the drill locations. Purge and development water will be discharged onto the ground surface at the well locations. Decontamination fluids will be discharged to the ground surface at the landfill.

4.9 SAMPLE HANDLING

Sample handling includes the field-related activities necessary to ensure that the samples are prepared, packaged, and shipped to the laboratory in an appropriate, well documented manner. Summaries of sample containers, volume requirements, preservatives, allowable holding times, and analyses are provided in Table 4-1.

4.9.1 Field Documentation and Sample Custody

Sample documentation consists of the completion of forms as shown in Appendix B to record pertinent information and to maintain sample custody. In addition, the Master Site Logbook serves as the overall record of field activities. Information included daily in the Master Site Logbook includes weather conditions, identity and arrival and departure times of personnel, management issues, etc.

4.9.2 Sample Nomenclature

Each sample collected at Site 13 will be assigned a unique tracking number. The sample number designation includes the sample location number, site number, and an indication of the sample matrix. The sample locations identified in Table 2-1 incorporate the sample matrix/type, site, and sample location numbers.

4.9.3 Sample Filtering

It may be necessary to filter groundwater samples for metals analyses in those cases where turbidity measurements are greater than 10 NTU's at the time of sample collection. The samples will be filtered using an .45µ inline filter and silicone tubing connected to a peristaltic pump. All filtering equipment will be dedicated and disposal. A rinsate blank of this equipment will not be necessary.

4.9.4 Sample Preservation

The existence of some chemical constituents in some environmental matrices is unstable. Therefore, these types of samples must be "stabilized" using preservatives and/or special handling procedures. These preservation techniques prevent degradation of the sample to ensure that the sample is representative of actual site conditions. Preservation requirements for samples to be collected at Site 13 are presented in Table 4-1.

4.9.5 Sample Packaging

The sample containers, once labeled and appropriately preserved, will be placed in Ziploc bags and placed in a cooler lined with a garbage bag. Crushed ice will be placed around the sample containers and the chain of custody form will be taped to the inside lid of the cooler. The cooler will be taped shut with chain of custody seals, and labeled for delivery to the lab. The sample cooler will be taken to the overnight courier for overnight shipping to the laboratory.

TABLE 4-1

SUMMARY OF FIELD AND LABORATORY ANALYSES
BOTTLEWARE, PRESERVATION, AND HOLDING TIMES
SITE 13
NWS EARLE, COLTS NECK, NEW JERSEY

Analysis	Method	Sample Volume	Container Material	Preservation	Holding Time
SEDIMENT					
Select VOCs	OLM04.3	40 mL	Glass vial	Hydrochloric Acid to pH <2, Cool to 4°C	14 days
Select Metals	ILM04.1	250 mL	Polyethylene	Nitric Acid to pH <2	180 Days
Chloride	EPA 300	250 ml	Polyethylene	Cool to 4° C	28 days
Dissolved Gases (Hydrogen, Ethane, Ethene, Methane)	RSK SOPs 147 and 175	3-40 ml sample vials	Glass	Hydrochloric Acid pH < 2, Cool to 4°C	14 days
Nitrate, Nitrite, Sulfate, and Sulfide	Hach DR-850	(1)	(1)	(1)	(1)
Ferrous Iron	Hach IR-18C	(1)	(1)	(1)	(1)
Dissolved Oxygen	Chemetrics K-7501, K-7512	(1)	(1)	(1)	(1)
Alkalinity	Chemetrics K-9810,K-9815, K-9820	(1)	(1)	(1)	(1)

(1) Not applicable, these methods are field analyses and are performed on site.
NOTE: Method number shall be indicated on the chain-of-custody form for laboratory analyses.

Measurements of temperature, specific conductance, ORP, dissolved oxygen, and turbidity will be recorded with a water quality meter.

5.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective for this project is to develop and implement procedures for field sampling, COC, laboratory analysis, and reporting that will provide results that are legally defensible in a court of law. Specific procedures for sampling, COC, laboratory instrument calibration, laboratory analysis, reporting of data, internal QC, audits, preventive maintenance of field equipment, and corrective action are described in other sections of this QAPP.

The PARCC parameters (precision, accuracy, representativeness, comparability, and completeness) are qualitative and/or quantitative statements regarding the quality characteristics of the data used to support project objectives and ultimately, environmental decisions. These parameters are discussed in the remainder of this section. Specific routine procedures used to assess the quantitative parameters (precision, accuracy, and completeness) are provided in Section 13.0 of this QAPP.

5.1 PRECISION

5.1.1 Definition

Precision is a measure of the amount of variability and bias inherent in a data set. Precision describes the reproducibility of measurements of the same parameter for samples under similar conditions. The equation for determining precision is provided in Section 13.2 of this QAPP.

5.1.2 Field Precision Objectives

Field duplicate precision monitors the consistency with which environmental samples were obtained and analyzed. Field duplicate results for sediment matrix samples are considered to be precise if the relative percent difference (RPD) is less than or equal to 50 percent. Field precision is assessed through the collection and measurement of field duplicates at a rate of 1 duplicate per 10 environmental samples or one duplicate per sampling day per matrix, whichever is greater.

5.1.3 Laboratory Precision Objectives

Laboratory precision QC samples are analyzed at a frequency of 5 percent (i.e., 1 quality control sample per 20 environmental samples). Laboratory precision is measured via comparison of calculated RPD values and precision control limits specified in the analytical method or by the laboratory's QA/QC Program.

The following analyses will be completed for environmental samples collected during the CEA Investigation at NWS Earle:

- Select Metals analysis via CLP ILM04.1 (see Table 4-1 note)
- Select VOC analysis via CLP OLM04.3
- Dissolved Gases via RSK SOPs 147/175
- Chloride via EPA Method 300.0

Precision for VOC organic and Chloride analyses will be measured via the RPDs for matrix spike/matrix spike duplicate (MS/MSD) samples. Precision for Metals and Gases analyses will be measured via RPDs for laboratory duplicates. RPD limits will be statistically derived at the analytical laboratory. These limits will be provided in each analytical data package.

5.2 ACCURACY

5.2.1 Definition

Accuracy is the degree of agreement between two results, which are the observed value and an accepted reference value. The equation for determining accuracy is provided in Section 13.1 of this QAPP.

5.2.2 Laboratory Accuracy Objectives

Accuracy in the laboratory is measured through the comparison of a spiked sample result against a known or calculated value expressed as a percent recovery (%R). %Rs are derived from the analysis of known amounts of compounds spiked into de-ionized water (i.e., laboratory control sample analysis) or into actual samples (i.e., surrogate or MS analysis). These analyses measure the accuracy of laboratory operations as affected by matrix. Laboratory control sample and/or MS analyses are performed with a frequency of 1 per 20 associated samples of like matrix. Surrogate spike analysis is performed for all organic analyses. Laboratory accuracy is assessed via comparison of calculated %R values with accuracy control limits specified in the analytical method or by the contracted laboratory's QA/QC Program.

The following analyses will be completed for environmental samples collected during the CEA Investigation at NWS Earle:

- Select Metals analysis via CLP ILM04.1 (see Table 4-1 note)
- Select VOC analysis via CLP OLM04.3
- Dissolved Gases via RSK SOPs 147/175
- Chloride via EPA Method 300.0

Accuracy for VOC analyses will be measured via the %Rs for surrogate spikes, LCS, and MS/MSDs. Accuracy for Metals analysis will be measured via %Rs for MS and laboratory control samples. Accuracy for Dissolved Gases analyses will be measured via LCS/LCSDs. Accuracy for Chloride analyses will be measured via MS/MSDs. QC limits for matrix and surrogate spike recoveries are statistically derived by the analytical laboratory and will be provided in each analytical data package.

5.3 COMPLETENESS

5.3.1 Definition

Completeness is a measure of the amount of usable, valid, analytical data obtained compared to the amount expected to be obtained. Completeness is typically expressed as a percentage.

The ideal objective for completeness is 100 percent (i.e., every sample planned to be collected is collected; every sample submitted for analysis yields valid data). However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed), errors can be introduced during analysis (e.g., loss of instrument sensitivity, introduction of ambient laboratory contamination), or strong matrix effects can become apparent (e.g., extremely low MS recovery). These instances result in data that do not meet QC criteria. Based on these considerations, 95 percent is considered an acceptable target for the data completeness objective. If critical data points are lost, re-sampling and/or reanalysis may be required.

One hundred percent of the data for the CEA Investigation activities shall be validated. The validation will be in accordance with the USEPA National Functional Guidelines for Organic and Inorganic Data Review and the USEPA Region II SOP for validation of data unless dictated otherwise by project-specific data quality objectives (DQOs). Data rejected as a result of the validation process will be treated as incomplete data.

5.3.2 Laboratory Completeness Objectives

Laboratory completeness is a measure of the amount of valid laboratory measurements obtained from all the laboratory measurements made in support of a given project. The equation for completeness is presented in Section 13.3 of this QAPP. Laboratory completeness for the NWS Earle CEA Investigation activities is expected to be at least 95 percent.

5.4 REPRESENTATIVENESS

5.4.1 Definition

Representativeness is an expression of the degree to which the data accurately and precisely depict the actual characteristics of a population or environmental condition existing at an individual sampling point. Use of standardized sampling, handling, analytical, and reporting procedures ensures that the final data accurately represent actual site conditions.

5.4.2 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analysis of field duplicate samples.

5.5 COMPARABILITY

5.5.1 Definition

Comparability is defined as the confidence with which one data set can be compared to another (e.g., between sampling points and between sampling events). Comparability is achieved by using standardized sampling and analysis methods and data reporting formats including use of consistent units of measure and reporting of solid matrix sample results on a dry-weight basis. Additionally, consideration is given to seasonal conditions and other environmental variations that could influence data results.

5.5.2 Measures to Ensure Comparability of Laboratory Data

Analytical data will be comparable when similar sampling and analytical methods are used and documented. Results will be reported in units that ensure comparability with previous data and with current State and federal standards and guidelines. VOC, Gases, Chloride, and Metals results will be reported as µg/L for groundwater samples. Detection, reporting, and quantitation limits are discussed in Section 2 of this QAPP.

5.6 LEVEL OF QUALITY CONTROL EFFORT

Trip blank, equipment blank, field blank, method blank, duplicate, and MS samples will be analyzed to assess the quality of the data resulting from the field sampling and analytical program.

External QC samples (i.e., field QC samples) consist of field duplicates, field blanks, trip blanks, and equipment (rinsate) blanks. Each of these types of field QC samples undergoes the same preservation, analysis, and reporting procedures as the related environmental samples. Each type of field QC sample is discussed below.

Field duplicates are either two samples collected independently at a sampling location (e.g., surface water), or a single sample homogenized and split into two portions. Field duplicates are collected and analyzed for chemical constituents to measure the precision of the sampling and analysis methods employed. The general level of the QC effort will be 1 field duplicate for every 10 or fewer investigative samples or one duplicate per matrix per sampling day, whichever is greater.

Field blanks (ambient condition blanks), consisting of source water, will be submitted to the laboratories to provide the means to assess the quality of the data resulting from the field sampling program. Field blank samples are analyzed to check for background contamination at the site that may cause sample contamination. Field blanks will be collected based on conditions at the time of sampling at the discretion of the FOL, with a minimum of one field blank being collected per individual contiguous area of potential concern.

Equipment (rinsate) blanks are obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and prior to use. One rinsate blank will be collected per each type of sampling equipment used (i.e., bailer, split-spoon sampler, hand tools, etc.) per day that sampling is conducted at a minimum frequency of 10 percent. A sampling event is matrix-specific; therefore, an equipment blank must be collected for each matrix sampled. If pre-cleaned, dedicated, or disposable sampling equipment is used, one rinsate blank must be collected as a "batch blank." Rinsate blanks are analyzed for the same chemical constituents as the associated environmental samples.

Method blank samples are generated within the laboratory and used to assess contamination resulting from laboratory procedures. Laboratory duplicate samples are analyzed for inorganic parameters to check for sampling and analytical reproducibility.

MS samples provide information about the effect of the sample matrix on the digestion and measurement methodology. All MS for organic analyses are performed in duplicate and are hereinafter referred to as MS/MSD samples. One MS/MSD will be analyzed for every 20 or fewer investigative samples per sample matrix (i.e., groundwater, soil).

The level of QC effort for testing of VOCs will conform to the CLP OLM04.3 guidelines. The level of QC effort for testing of Metals will conform to CLP ILM04.1.

6.0 CUSTODY PROCEDURES

Documented sample custody is one of several factors necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all original laboratory reports and purge files, are maintained under document control in a secure area. A sample or evidence file is under custody when any one of the following conditions is satisfied:

- The item is in the actual physical possession of an authorized person.
- The item is in view of the person after being in his or her possession.
- The item was placed in a secure area to prevent tampering.
- The item is in a designated and identified secure area with access restricted to authorized personnel only.

The COC form is a multi-part, standardized form used to summarize and document pertinent sample information such as sample identification and type, sample matrix, date and time of collection, preservation, and requested analyses. Furthermore, through the sequential signatures of various sample custodians (e.g., sampler, airbill number, laboratory sample custodian), the COC form documents sample custody and tracking. Laboratory custody procedures will ensure that sample integrity is not compromised from the time of receipt at the laboratory until final data are reported to TtNUS. This requires that the laboratory control all sample handling and storage conditions and circumstances. Custody procedures apply to all environmental and associated field QC samples obtained as part of the data collection system.

6.1 FIELD CUSTODY PROCEDURES

The FOL (or designee) is responsible for the care and custody of the samples collected until they are relinquished to the laboratory or entrusted to a commercial courier. COC forms are completed to the fullest extent possible for each sample cooler used for shipment. The forms are legibly completed with waterproof ink and are signed and dated by the sampler. COC forms will include the following information: project name, sample number, time collected, matrix, designated analyses, type of sample, preservative, and name of sampler. Pertinent notes or comments are also indicated on the COC form.

Information similar to that contained on the COC form is provided on the sample label, which is securely attached to the sample bottle. Sample labels will include, at a minimum, the following information: sample number, date and time of collection, analysis required for the sample aliquot in the associated sample container, and a space for the laboratory sample number. The procedures for sample numbering are listed in SOP CT-04 in Appendix C of this QAPP.

Site conditions during sampling and the care with which samples are handled may factor into the degree to which samples represent the media from which they are collected. This, in turn, could affect the ability of decision makers to make accurate and timely decisions concerning the contamination status of the site. As appropriate, logbooks are assigned to, and maintained by, key field team personnel. The logbooks are used to record daily conditions and activities such as weather conditions, dates and times of significant events, level of PPE used, actual sample collection locations, photographs taken, problems encountered during field activities, chemical screening results, and corrective actions taken to overcome problems. In addition, the names of site visitors and the purposes of their visits shall be recorded. Field logbook assignments shall be recorded in the site logbook or other central file, the location of which is known by the FOL and PM. During field activities, the FOL is responsible for the maintenance and security of all field records. At the completion of field activities, the FOL will forward all field records to the TtNUS PM. All field sample records will eventually be docketed into the final evidence file.

A temperature blank shall be included in each cooler containing samples for use by the laboratory upon receipt. Each cooler shall be taped shut with strapping tape in at least two places to prevent tampering. Custody seals shall be attached so that the seals must be broken to open the cooler. Samples for chemical analysis will be sent for next-day receipt to the laboratory within 24 hours of collection.

The following procedures will be used when transferring custody of samples. As previously noted, individual custody records will accompany each sample cooler. The method of shipment, courier name, and other pertinent information will be entered in the remarks section of the custody record. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC record. The original record (top copy of the multi-part form) will accompany the shipment, and the field sampler will retain a copy. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common courier). After COC records have been placed within sealed shipping coolers, the signed courier airbills will serve to document COC. When samples arrive at the laboratory, internal laboratory sample custody procedures will be followed (see Section 6.2).

6.2 LABORATORY CUSTODY PROCEDURES

Upon laboratory receipt of a shipment of samples, the laboratory's sample custodian will verify that the correct number of coolers has been received. The custodian will examine each cooler's custody seals to verify that they are intact and that the integrity of the environmental samples has been maintained. The custodian will then open each cooler and measure its internal temperature by measuring the temperature of the temperature blank. The temperature reading will be documented. The sample custodian will then sign the COC form and examine the contents of the cooler. Identification of broken sample containers or discrepancies between the COC form and sample labels will be recorded. The laboratory will retain the original field COC forms, providing copies of the forms with the final data package deliverable. All problems or discrepancies noted during sample receipt will be promptly reported to the TtNUS PM. Samples will be logged into the laboratory information management system.

6.3 FINAL EVIDENCE FILES

The TtNUS Central File will be the repository for all documents that constitute evidence relevant to sampling and analysis activities described in this QAPP. TtNUS will be the custodian of the evidence file and will maintain the contents of these files, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, and data reviews in a secure, limited-access location and under custody of the TtNUS QAM. The control file will include at a minimum:

- Field logbooks
- Field data and data deliverables
- Photographs and negatives
- Drawings
- Laboratory data deliverables
- Data validation reports
- Data assessment reports
- Progress reports, QA reports, interim project reports, etc.
- All custody documentation (tags, forms, airbills, etc.)
- Sample log sheets
- FTMR
- Corrective actions documentation.

Upon completion of the contract, all files associated with this investigation will be relinquished to the custody of the Navy.

The FOL will be responsible for ensuring the completion of the following forms:

- Sample labels
- COC forms
- COC seals for coolers

- Shipping labels for coolers
- Public courier air bills

6.4 QUALITY CONTROL SAMPLES

Field QC samples will be collected or generated during environmental sampling activities. Field QC samples will be addressed in more detail in Sections 5.6 and 9.2.

6.5 RECORD KEEPING

In addition to COC records, certain standard forms will be completed for sample description and documentation. These forms shall include sample log sheets, daily activity records, and logbooks. A bound, weatherproof notebook shall be maintained by the FOL. All information related to sampling or field activities will be recorded in the field notebook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, and field measurements. Field notebooks should also contain qualitative or semi-qualitative information on sample conditions such as odor and color. Record keeping is discussed in further detail in SOP SA-6.3 in Appendix C of this QAPP.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

All instrumentation used to perform chemical measurements must be properly calibrated prior to use in order to obtain valid and usable results. The requirement to properly calibrate instruments prior to use applies equally to field instruments as it does to fixed laboratory instruments. Laboratory instrument calibration is discussed in Section 7.1. The field staff will utilize photo-ionization detectors for health and safety reasons only. Because none of these measurements will be used to support the objectives, they are not considered field measurements.

7.1 LABORATORY INSTRUMENT CALIBRATION

Calibration procedures for a specific laboratory instrument will consist of initial calibration (generally three to five points), initial calibration verification (inorganic methods only), and continuing calibration verification and will comply with the analytical methods. In all cases, the initial calibration will be verified using an independently prepared calibration verification solution. The frequency of calibration will be performed according to the requirements of the specific methods.

All standards used to calibrate analytical instruments must be obtained from the National Institute of Standards and Technology (NIST) or through a reliable commercial supplier with a proven record for quality standards. All commercially supplied standards must be traceable to NIST reference standards, where possible, and appropriate documentation will be obtained from the supplier. In cases where documentation is not available, the laboratory will analyze the standard and compare the results to a USEPA-supplied known or previous NIST-traceable standard.

The calibration procedures and frequencies used by the subcontract laboratory will comply with the applicable analytical method. Brief descriptions of calibration procedures for the pertinent instrument types follow.

7.1.1 Volatile Organic Compounds Analyses

For VOC analyses, the GC/MS system will be calibrated in accordance with CLP OLM04.3. The initial calibration is required before any samples are analyzed, and a multi-point initial calibration sequence is analyzed. A five-point initial calibration with standards bracketing the range of detection (for VOCs and a one-point calibration factor is determined). If all initial calibration criteria are met, samples may be analyzed for a period of 12 hours. The calibration must be verified (continuing calibration every 12 hours). Calibration standards must be injected after every 20 samples. If continuing calibration criteria are met, analysis of samples can continue. If continuing calibration criteria are not met it is necessary to recalibrate.

7.1.2 Metals Analyses

7.1.2.1 Inductively Coupled Argon Plasma Analyses

Inductively coupled plasma (ICP) spectrometry systems will be calibrated for the analysis of metals in accordance with the CLP protocols outlined in Method ILM04.1. Initial calibration is required each day before any samples are analyzed and consists of a calibration blank and at least one standard. Following initial calibration, an initial calibration verification sample (obtained from a different source than the solutions used for calibration), an initial calibration blank, and an interference check sample are analyzed. A continuing calibration verification sample and a continuing calibration blank are run every 2 hours or every 10 samples, whichever occurs first. A continuing calibration verification sample, a continuing calibration blank, and an interference check sample are also run after analysis of the last sample. The initial calibration verification standard, continuing calibration verification standard, and interference check sample each contain analytes of interest at different concentrations. The calibration verification standards must agree within 10 percent of their known values and must have a relative percent difference of less than 5 percent for the calibration to be considered valid. All calibration standards contain acids at the same concentrations as the sample digestates.

7.1.3 Dissolved Gases Analyses

For Dissolved Gases analyses, the GC system will be calibrated in accordance with RSK SOPs 147/175. The initial calibration is required before any samples are analyzed, and a multi-point initial calibration sequence is analyzed. A five-point initial calibration with standards bracketing the range of detection (for VOCs and a one-point calibration factor is determined). If all initial calibration criteria are met, samples may be analyzed for a period of 12 hours. The calibration must be verified (continuing calibration every 12 hours). Calibration standards must be injected after every 20 samples. If continuing calibration criteria are met, analysis of samples can continue. If continuing calibration criteria are not met it is necessary to recalibrate.

7.1.4 Inorganic Anions Analyses

For Inorganic Anions analyses, the Ion Chromatography (IC) system will be calibrated in accordance with EPA Method 300.0. The initial calibration is required before any samples are analyzed, and a multi-point initial calibration sequence is analyzed. A minimum of a three-point initial calibration plus a blank with standards bracketing the range of detection is performed. If all initial calibration criteria are met, samples may be analyzed for a period of 12 hours. The calibration must be verified (continuing calibration every

12 hours). Calibration standards must be injected after every 20 samples. If continuing calibration criteria are met, analysis of samples can continue. If continuing calibration criteria are not met it is necessary to recalibrate.

7.2 MISCELLANEOUS FIELD ANALYSES

Miscellaneous Field Analyses (Nitrate, Nitrite, Sulfate, Sulfide, Ferrous Iron, Dissolved Oxygen, and Alkalinity) will be performed using field test kits. The preparation and analyses will be performed according to the manufacturers' guidelines.

8.0 ANALYTICAL AND MEASUREMENT PROCEDURES

The analytical laboratory has yet to be determined, however, QA/QC control limits are provided in the CLP Methodology which may be utilized to perform the majority of the routine chemical analyses for the environmental samples to be collected as part of this investigation.

8.1 LABORATORY ANALYTICAL AND MEASUREMENT PROCEDURES

Select Volatiles and select Metals will be analyzed in accordance with the CLP analytical procedures set forth in the CLP Methods OLM04.3 and ILM04.1, respectively. Dissolved Gases will be analyzed in accordance with the analytical procedures set forth in RSK SOPs 147/175. Chloride will be analyzed in accordance with the analytical procedures set forth in EPA Method 300.0.

8.1.1 List of Project Target Compounds and Detection Limits

Table 8-1 provides a summary of the preparation, clean-up, and analytical methods for the anticipated activities. A complete list of the target compounds/analytes, CRDLs, and CRQLs is provided in Section 2 of this QAPP. Organics data generated through use of CLP protocols will be reported to the CRDL. Metals data generated through use of CLP protocols will be reported to the CRQL. Quantitation and detection limits will also be adjusted, as necessary, based on dilutions and sample volume.

Non-detects will be reported to the CRDL/CRQL for metals and to the PQL for dissolved gases and anions and marked with a "U" flag as applicable. Positive results between the CRDL/CRQL/PQL and method detection limit/instrument detection limit will be flagged "J".

8.1.2 List of Associated Quality Control Samples

In addition to the field QC samples (duplicates, trip blanks, rinsate blanks, etc.) discussed in Sections 5.6 of this QAPP, laboratory QC samples including MS/MSD samples, method blanks, preparation blanks, etc. will be analyzed as required by the appropriate methods. Laboratory QC samples are discussed in additional detail in Section 9.2 of this QAPP.

8.2 FIELD ANALYTICAL AND MEASUREMENT PROCEDURES

Nitrate, Nitrite, Sulfate, Sulfide, Ferrous Iron, Dissolved Oxygen, and Alkalinity will be analyzed using field test kits as defined in Table 4-1. The analyses will be performed according to the manufacturers' guidelines.

TABLE 8-1

SUMMARY OF ORGANIC AND INORGANIC ANALYTICAL PROCEDURES
GROUNDWATER MATRIX
NWS EARLE, NEW JERSEY

Analytical Parameter	Preparation/Analytical Method
Select VOCs	CLP OLM04.3(1)
Select Metals	CLP ILM04.1(2)
Chloride	EPA 300.0(3)
Methane, Ethane, Ethene, and Hydrogen	RSK SOPs 147/175(4)
Sulfate, Sulfide, Nitrate, and Nitrite	HACH DR-850(5)
Ferrous Iron	HACH IR-18C(5)
Dissolved Oxygen	Chemetrics K-7501, K-7512(5)
Alkalinity	Chemetrics K-9810, K-9815, K-9820(5)

1 USEPA Contract Laboratory Program. Statement of Work for Organics Analysis; Multi-Media, Multi-Concentration, OLM04.3.
2 USEPA Contract Laboratory Program. Statement of Work for Inorganic Analysis; Multi-Media, Multi-Concentration, ILM04.1.
3 USEPA Method 300.0. Inorganic Anions by Ion Chromatography.
4 Dissolved Gases: Ethane, Ethene, Methane, and Hydrogen in Groundwater. Robert S. Kerr Environmental Research Laboratory SOPs 147/175.
5 Analyses performed using field test kits.

VOC = Volatile Organic Compounds

9.0 INTERNAL QUALITY CONTROL CHECKS

Field-related QC checks were discussed in Section 4.0 of this QAPP. This section provides additional information regarding internal QC checks for the field and the laboratory.

9.1 FIELD QUALITY CONTROL CHECKS

Collection of the field QC samples will be in accordance with the sampling procedures provided in this QAPP at the frequencies discussed in Section 4.0 of this QAPP.

9.2 LABORATORY QUALITY CONTROL CHECKS

The subcontract laboratory will have a QC program that ensures the reliability and validity of the analyses performed at the laboratory. All analytical procedures are typically documented in writing as SOPs. Laboratory SOPs for any and all analyses will be provided in either addenda to the QAPP or under separate cover contingent upon the logistics of the laboratory procurement process.

Internal QC procedures for CLP analyses (VOC and metals) are discussed in OLM04.3 and ILM04.1. Internal QC procedures for Dissolved Gases (methane, ethane, ethene, and hydrogen) are discussed in RSK SOP-147/175. Internal QC procedures for chloride are discussed in EPA Method 300.0. Several internal laboratory QC checks are briefly discussed in the remainder of this section.

Laboratory method blanks are prepared and analyzed in accordance with the analytical method employed to determine whether contaminants originating from laboratory sources have been introduced and have affected environmental sample analyses. A method blank generally consists of an aliquot of analyte-free water that is subjected to the same preparation and analysis procedures as the environmental samples undergoing analysis. If method blank contamination is found to exist, corrective actions indicated in the CLP/EPA Methods or laboratory SOPs must be followed. Under no circumstances are laboratory method blank contaminant values subtracted from environmental sample analysis results.

MS analysis for VOC fraction analyses is performed in duplicate as a measure of laboratory precision. For inorganic analyses, 1 **laboratory duplicate** analysis is likewise performed for every 20 environmental sample analyses of like matrix. Laboratory duplicates are prepared by thoroughly mixing and splitting a sample aliquot into two portions and analyzing each portion following the same analytical procedures used for the environmental sample analyses. The field crew provides extra volumes of sample matrices designated for laboratory QC analyses, as required. The laboratory SOPs and CLP/EPA Methods define circumstances under which corrective actions are warranted and how they must be performed when required.

Surrogates are organic compounds (typically brominated, fluorinated, or isotopically labeled) that are similar in nature to the compounds of concern and that are not likely to be present in environmental media. Surrogates are spiked into each sample, standard, and method blank prior to analysis and are used only in organic chromatographic analysis procedures as a check of method effectiveness. Surrogate recoveries are evaluated against laboratory-derived statistical control limits.

LCSs serve to monitor the overall performance of each step during the analysis, including the sample preparation. LCS analysis will be performed for Metals, chloride, and dissolved gases analyses. Aqueous LCS results must fall within the control limits established by CLP/EPA Methodology for metals and laboratory SOP for dissolved gases. Aqueous LCSs shall be analyzed utilizing the same sample preparations, analytical methods, and QA/QC procedures as employed for the samples.

TABLE 9-1

CLP QC SAMPLE CRITERIA
NWS EARLE, NEW JERSEY

Compound	MS/MSD	LCS	Precision
VOC QC LIMITS			
System Monitoring Compounds			
Toluene-d8	84%-138%	NA	NA
Bromofluorobenzene	59%-113%	NA	NA
1,2-Dichloroethene-d4	70%-121%	NA	NA
Spiked Compounds			
1,1-Dichloroethene	61%-145%	NA	14%
Trichloroethene	71%-120%	NA	14%
Benzene	76%-127%	NA	11%
Toluene	76%-125%	NA	13%
Chlorobenzene	75%-130%	NA	13%
METALS QC LIMITS			
All Metals	75%-125%	80%-120%	20%

10.0 DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the procedures to be used for data reduction, validation, and reporting for the NWS Earle Groundwater CEA Investigation. All data generated during the course of the investigation will be maintained in portable document format (PDF) format by TtNUS in the Engineering Field Activity Northeast designated central files located in the TtNUS Pittsburgh, Pennsylvania office.

In addition to the central files, PDF's of all data (as well as electronic data) will be maintained in the Chemistry/Toxicology/Risk Assessment Department database records files located in the TtNUS Pittsburgh, Pennsylvania office. Upon completion of the contract, files will be relinquished to the Navy.

10.1 DATA REDUCTION

Data reduction will be completed for laboratory-generated analytical data. Reduction of laboratory data is discussed in the remainder of this section.

10.1.1 <u>Laboratory Data Reduction</u>

Data reduction for laboratory analytical data generated via the CLP analytical protocol, QA requirements, and reporting procedures (volatile organics, dissolved gases, chloride, and metals) will be completed in accordance with the applicable analytical methods.

Laboratory analytical data will be reported using standard concentration units to ensure comparability with regulatory standards/guidelines and previous analytical results. Reporting units for groundwater matrix for the classes of chemicals under consideration are as follows:

- volatile organics - µg/L
- metals - µg/L
- gases - µg/L
- chloride - mg/L

Field QC sample results will be included in the database for the NWS Earle Groundwater CEA Investigation. Specifically, the analytical results for field duplicates, source water blanks, trip blanks, rinsate blanks, and ambient condition blanks will be provided. The results for field QC samples will be considered during the course of data validation (in concert with laboratory method blanks) to eliminate false positive results according to the 5- and 10-times rules specified in the National Functional Guidelines for Organic and Inorganic Data Review. The results for laboratory QC samples such as method blanks will not be presented in the CEA Investigation Report database. In addition, only the original (unspiked) sample results for MS/MSD samples will be provided in the database.

10.2 DATA VALIDATION

Validation of field measurements and laboratory analytical data are discussed in this section. Laboratory analytical data will be validated in accordance with current state and regional EPA guidance as discussed in Section 10.2.1.

10.2.1 Laboratory Data Validation

One hundred percent of the laboratory data will be validated. Validation of analytical data will be completed by the TtNUS Chemistry Department located in TtNUS's Pittsburgh, Pennsylvania office. Final review and approval of validation deliverables will be completed by the Department's Data Validation Coordinator.

The analytical results for VOC and metals fractions generated using CLP methodology will be validated against method-specific requirements, National Functional Guidelines for Organic and Inorganic Data Review, USEPA Region II SOP for Data Validation, and the appropriate New Jersey DEP data validation SOPs to the extent practicable.

10.3 DATA REPORTING

10.3.1 Laboratory Data Reporting

Data reported by the laboratory will be in accordance with CLP reporting format including all non-CLP data (to the extent practicable). All pertinent QC data including raw data and summary forms for blanks, standards analysis, calibration information, etc., will be provided for the non-CLP analyses. Case narratives will be provided for each Sample Delivery Group.

All environmental and field QC sample results (trip blanks, field duplicates, rinsate blanks, source water blanks, ambient condition blanks) will be included in the report as an appendix. The database will include pertinent sampling information such as sample number, sampling date, general location, depth, and survey coordinates (if applicable). Sample-specific reporting limits will be reported for nondetected analytes. Units will be clearly summarized in the database and will conform to those identified in Section 10.1.1. The analytical data may also be reported in summary fashion within the body of the report text in tabular and graphic fashion.

Data will be handled electronically pursuant to the electronic deliverable requirements specified in TtNUS's Master Services Agreement with analytical laboratories. This agreement requires the analytical laboratories to provide data in both hardcopy and electronic form. The original electronic diskettes and the original hardcopy analytical data are maintained in TtNUS's Engineering Field Activity Northeast central files as received.

Validation will be completed using the PDF file data. Upon completion of validation of a Sample Delivery Group and review by the Data Validation Coordinator, the validation qualifiers will be entered in the electronic database and will be subjected to independent review for accuracy. During this review process, the electronic database printout will also be compared to the PDF data (Form Is) to ensure that the PDF data and electronic data are consistent.

11.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits will be performed periodically to ensure that work is being implemented in accordance with the approved Project Plans and in an overall satisfactory manner. Such audits will be performed by various personnel and will include evaluation of field, laboratory, data validation, and data reporting processes. Examples of pertinent audits are as follows:

- Performance and system audits of the laboratory will be performed regularly, in accordance with the requirements of NJDEP (external, annual evaluation), by a Navy Contractor (internal, 18 month cycle), and in accordance with the Laboratory Quality Assurance Plan (internal, as specified).

- Data validators will review (on a timely basis) the chemical analytical data packages submitted by the laboratory. The data validators will check that the data were obtained through use of an approved methodology, that the appropriate level of QC effort and reporting was conducted, and whether or not the results are in conformance with QC criteria. On the basis of these factors, the data validator will generate a report describing data limitations, which will be reviewed internally by the Data Validation Coordinator prior to submittal to the PM.

- A formal audit of the field sampling procedures may be conducted by the TtNUS QAM or designee in addition to the auditing that is an inherent part of the daily project activities. The purpose of this audit would be to ensure that sample collection, handling, and shipping protocols, equipment decontamination and field documentation procedures are being performed in accordance with the approved Project Plans and SOPs.

- A sample tracking system, as further described in Section 4 of the QAPP, will be employed for all environmental samples. This system will allow for early detection of errors made in the field or by the laboratory so that necessary adjustments can be made while the field crew is mobilized.

The PM will maintain contact with the FOL and Data Validation Coordinator to ensure that management of the acquired data proceeds in an organized and expeditious manner.

12.0 PREVENTIVE MAINTENANCE PROCEDURES

Measuring equipment used in environmental monitoring or analysis for the NWS Earle CEA Investigation shall be maintained in accordance with the manufacturer's operation and maintenance manuals. Equipment and instruments shall be calibrated in accordance with the procedures, and at the frequencies, discussed in Section 7.0 (Calibration Procedures and Frequency). Preventive maintenance for laboratory equipment is discussed in the remainder of this section.

12.1 LABORATORY INSTRUMENT PREVENTIVE MAINTENANCE

Proper maintenance of laboratory instruments and equipment is essential to ensuring their readiness when needed. Maintenance intervals are established for each instrument based on manufacturer's recommendations. All instruments must be labeled with a model number and serial number, and a maintenance logbook must be maintained for each instrument. Personnel must be alert to the maintenance status of the equipment they are using at all times.

12.1.1 Major Instruments

Table 12-1 provides a summary of preventive maintenance procedures typically performed for key analytical instruments. Maintenance of key instruments is sometimes covered under service contracts with external firms. These contracts provide for periodic routine maintenance to help guard against unexpected instrument downtime. The contracts also provide for quick response for unscheduled service calls when malfunctions are observed by the operator.

The use of manufacturer-recommended grades or better of supporting supplies and reagents is also a form of preventive maintenance. For example, gases used in the various GC and metals instruments should be of sufficient grade to minimize fouling of the instrument. The routine use of septa, chromatographic columns, ferrules, atomic absorption furnace tubes, and other supporting supplies from reputable manufacturers will assist in averting unnecessary periods of instrument downtime.

12.1.2 Refrigerators/Ovens

The temperatures of refrigerators used for sample storage and drying ovens will be monitored a minimum of once daily. The acceptable range for refrigerator temperatures is 4°C ±2°C. Required temperatures of ovens will vary based on the analytical methods for which the ovens are used. The temperatures will be recorded on temperature logs that contain the following information at a minimum:

- Date
- Temperature
- Initials of person performing the check

Maintenance of the logs is typically the responsibility of the sample custodian. However, assignment of responsibilities for temperature monitoring to specific personnel does not preclude the participation of other laboratory personnel. If unusual temperature fluctuations are noted, it is the responsibility of the observer to immediately notify the person in charge of the discrepancy before the condition of the samples is compromised.

Unstable or fluctuating temperatures may be indicative of malfunctions in the cooling or heating system. On the other hand, the instability may be due to frequent opening of the door. Regardless of the cause, such an observation must be investigated, and modifications must be made to access procedures or repairs to equipment must be made to prevent jeopardizing the integrity of the samples.

TABLE 12-1

TYPICAL PREVENTIVE MAINTENANCE FOR KEY ANALYTICAL INSTRUMENTS
NWS EARLE, COLTS NECK, NEW JERSEY

Instrument	Preventive Maintenance	Maintenance Frequency
GC	Replace solvent washes and clean syringe.	Daily.
	Clip column, clean injection port, replace liner, and bake oven.	As required.
GC/MS	Change pump oil.	Every 6 months
	Change septum. Clean injection port, replace liner, bake oven, check carrier gas, clean the ion source.	As needed
	Clean source and rods, clean inside and outside of printer, general cleaning of instrument.	As needed
	Service in accordance with manufacturer specifications under the contractor maintenance agreement.	As needed
	Replace solvent washes and clean syringe.	Daily
Ion Chromatograph	Replace pump seals.	Annually.
	Lubricate analytical pump motor.	Semi-annually.
	Check chromatography module and all gas lines for leaks.	Every run.
	Clean conductivity detector cell electrodes, check cell calibration.	Monthly.
	Replace bed supports, clean columns, clean membrane suppressor, replace autosampler pipette tip.	As needed.
ICP	Change sample introduction tubing, clean nebulizer, clean spray chamber, clean torch, manual profile, and automatic profile optics.	As required.

13.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS

The purpose of this section is to indicate the methods by which it will be ensured that the data collected for this investigation coincide with the project objectives as specified in Section 2 of this QAPP. The data assessment will be conducted to evaluate analytical data quality via compliance with the QA objectives addressed in Section 5.0 of this QAPP. Additionally, the data will be reviewed for indications of interferences to results caused by sample matrices, cross contamination during sampling, cross contamination in the laboratory, and sample preservation and storage anomalies.

The data validation process will be used to flag data with quality indicators that fall outside the QC acceptance limits. A summary of the data validation qualifiers for all project samples will be prepared. This summary will include a list of chemicals identified as laboratory and/or field QC blank contaminants, holding time exceedances, samples exhibiting field duplicate/replicate imprecision as well as affected chemicals, rejected results and associated specific causes, and general causes of estimated results. This summary will facilitate the preparation of a summary of the data validation results and completeness assessment for inclusion in the report.

Compliance with the completeness objectives for laboratory measurements/data will be calculated electronically via a database subroutine. Sections 13.1, 13.2, and 13.3 present equations to be used for computing precision, accuracy, and completeness values, respectively. Section 13.4 presents additional data quality considerations that will be evaluated after completion of data validation.

13.1 ACCURACY ASSESSMENT

As described in Sections 5.2.2 and 9.2, to assure the accuracy of the analytical procedures, a minimum of 1 of every 20 samples is spiked with a known amount of the analyte or analytes to be evaluated. The spiked sample is then analyzed. The increase in concentration of the analyte observed in the spiked sample because of the addition of a known quantity of the analyte compared to the reported value of the same analyte in the unspiked sample determines the %R. Control charts are plotted by the laboratory for each commonly analyzed compound and kept on matrix-specific and analyte-specific bases. The %R for a spiked sample is calculated according to the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Unspiked Sample}}{\text{Known Amount Added}} \text{ X } 100\ \%$$

Section 9.2 also describes the use of surrogate spikes and LCSs as measures of accuracy. The %R for a surrogate spike or LCS is calculated using the following formula:

$$\%R = \frac{\text{Experimental Concentration}}{\text{Known Amount Added}} \text{ X } 100\%$$

13.2 PRECISION ASSESSMENT

As described in Sections 5.1.1 and 9.2, duplicate samples (for inorganic analyses) and MSD samples (for organic analyses) are prepared and analyzed at a minimum frequency of 1 per every 20 environmental samples. As addressed in Section 5.6, field duplicate samples will also be collected at a minimum frequency of 1 per 10 environmental samples. The RPD between the sample (or spike) and duplicate (or duplicate spike) is calculated using the following formula:

$$RPD = \frac{\text{Amount in Sample 1} - \text{Amount in Sample 2}}{0.5\,(\text{Amount in Sample 1} + \text{Amount in Sample 2})} \text{ X } 100\%$$

13.3 COMPLETENESS ASSESSMENT

As addressed in Section 4.3, completeness is the ratio of the number of valid sample results to the total number of sample results expected to be obtained for the project as a whole. Following the completion of the analytical testing and data validation, the percent completeness will be calculated using the following equation:

$$\text{Completeness} = \frac{\text{(number of valid measurements)}}{\text{(number of measurements planned}} \text{ x } 100\%$$

13.4 DATA ASSESSMENT

The laboratory data collected during the NWS Earle CEA Investigation will be used to meet the objectives presented in Section 2 of this QAPP. The QC results associated with each analytical parameter (only one) will be compared with the objectives presented in Sections 5.1 though 5.5 of this QAPP. Only data deemed usable during data validation will be considered usable for quantitative purposes.

In addition, the data obtained will be both qualitatively and quantitatively assessed. The results of this assessment will be presented in the NWS Earle CEA Investigation Report. Examples of issues to be considered in the data assessment are as follows:

- Were all samples obtained using the methodologies and SOPs specified in the SAP/QAPP?
- Were samples obtained from all sampling locations for all analyses specified in the SAP/QAPP?
- Were all laboratory analyses performed using the methodologies specified in the QAPP?
- Was all laboratory data validated as specified in the QAPP?
- Do any analytical results exhibit elevated reporting limits? If so, what are the causes and what overall impact does this have on the data?
- Were any data points determined to be unusable (qualified as "R") during the data validation process? If so, are these rejected data points critical in meeting the objectives of the project?
- Have sufficient data of appropriate quality been generated to support the objectives described in Section 2 of the QAPP?

14.0 CORRECTIVE ACTION

Under the TtNUS QA/QC program, it is required that any and all personnel noting conditions adverse to quality report these conditions immediately to the PM and QAM. These parties, in turn, are charged with performing root-cause analyses and implementing appropriate corrective action in a timely manner. It is ultimately the responsibility of the QAM to document all findings and corrective actions taken and to monitor the effectiveness of the corrective measures performed.

14.1 FIELD CORRECTIVE ACTION

Field nonconformances or conditions adverse to quality must be identified and corrected as quickly as possible so that work integrity or product quality is not compromised. The need for corrective action may arise based on deviations from Project Plans and procedures, adverse field conditions, or other unforeseen circumstances. Corrective action needs may become apparent during the performance of daily work tasks or as a consequence of internal or external field audits.

Corrective action may include resampling and may involve amending previously approved field procedures. If warranted by the severity of the problem (e.g., if a change in the approved Project Plan documents or SOPs is required), the Navy will be notified in writing via a field task modification request (FTMR), and Navy (in conjunction with USEPA Region II and NJDEP) approvals will be obtained. The FOL is responsible for initiating FTMRs; an FTMR will be initiated for all deviations from the Project Plan documents, as applicable. An example of an FTMR is provided as Figure 14-1. Copies of all FTMRs will be maintained with the on-site project planning documents and will be placed in the final evidence file.

Minor modifications to field activities such as a slight offset of a sampling location will be initiated at the discretion of the FOL, subject to on-site approval by NWS Earle personnel. Approval for major modifications (e.g., elimination of a sampling point) must be obtained via an FTMR.

14.2 LABORATORY CORRECTIVE ACTION

In general, laboratory corrective actions are warranted whenever an out-of-control event or potential out-of-control event is noted. The specific corrective action taken depends on the specific analysis and the nature of the event. Generally, the following occurrences alert laboratory personnel that corrective action may be necessary:

- QC data are outside established warning or control limits.
- Method blank analyses yield concentrations of target analytes greater than acceptable levels.

- Undesirable trends are detected in spike recoveries or in duplicate RPDs.
- There is an unexplained change in compound detection capability.
- Inquiries concerning data quality are received.
- Deficiencies are detected by laboratory QA staff audits or from performance evaluation sample test results.

Corrective actions are typically documented for out-of-control situations on a corrective action form. Using a corrective action form, any employee may notify the QA/QC Officer of a problem. The QA/QC Officer generally initiates the corrective action by relating the problem to the appropriate Laboratory Manager and/or Internal Coordinator, who then investigates or assigns responsibility for investigating the problem and its cause. Once determined, an appropriate corrective action is approved by the QA/QC Officer, its implementation is verified and documented on the corrective action form and it is further documented through audits.

14.3 CORRECTIVE ACTION DURING DATA VALIDATION AND DATA ASSESSMENT

The need for corrective action may become apparent during data validation, interpretation, or presentation activities or problems may be identified as a result of oversight findings. The performance of rework, instituting a change in work procedures, or providing additional/refresher training are possible corrective actions relevant to data evaluation activities. The PM will be responsible for approving the implementation of corrective action.

FIGURE 14-1

TETRA TECH NUS
FIELD TASK MODIFICATION REQUEST FORM

____

Client Identification | Project Number | FTMR Number

To_________________________________ Location___________________ Date________________

Description:

____
____
____
____

Reason for Change:

____
____
____
____

Recommended Disposition:

____
____
____
____

____
Field Operations Leader (Signature, if applicable) Date

Disposition:

____
____
____
____

____
Project Manager (Signature, if required) Date

____
Distribution:
Program Manager
Quality Assurance Officer
Project Manager
Field Operations Leader______

Others as required____________________________
____
____

15.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

QA reports to management will be provided in three primary formats during the course of the NWS Earle CEA Investigation. Data validation letter reports will be prepared on a Sample Delivery Group-specific basis and will summarize QA issues for the subcontract laboratory data. In addition, daily verbal reports summarizing accomplishments and QA/QC issues during the field investigation will be provided by the FOL. Finally, monthly progress reports are provided by the PM to the Navy. In addition, a summary of data validation qualifiers and a completeness assessment for all project samples will be included in the CEA Investigation Report.

15.1 CONTENTS OF PROJECT QUALITY ASSURANCE REPORTS

The contents of the specific QA reports are as follows. The data validation reports address all major and minor laboratory noncompliances as well as noted sample matrix effects. In the event that major problems occur with the analytical laboratory (e.g., holding time exceedances or calibration noncompliances, etc.), the Data Validation Coordinator will notify the PM, the Program Manager, and the Laboratory Services Coordinator. Such notifications (if necessary) are typically provided via internal memoranda and are placed in the project file. Such reports contain a summary of the noncompliance, a synopsis of the impact on individual projects, and recommendations regarding corrective action and compensational adjustments. Corrective actions are initiated at the program level.

The FOL will provide the PM with daily reports via telephone regarding accomplishments, deviations from the QAPP, upcoming activities, and a QA summary during the course of the field investigation. In addition, monthly project review meetings are held for all active Navy CLEAN projects. Issues discussed at the project review meeting include all aspects of budget and schedule compliance and QA/QC problems. The PM provides a monthly progress report to the Navy that addresses the project budget, schedule, accomplishments, planned activities, required revisions of the QAPP, QA/QC issues, and intended corrective actions.

15.2 INDIVIDUALS RECEIVING/REVIEWING QUALITY ASSURANCE REPORTS

Data validation QA Reports are provided to the PM for inclusion in the project files. In the event that major problems are observed for a given laboratory, the Program Manager, Deputy Program Manager, QAM, PM, and Laboratory Services Coordinator are provided with copies of the QA report. Weekly field progress reports are provided to the PM by the FOL. Monthly progress reports are provided to the Navy CLEAN Program Manager and the Navy CLEAN Contracting Officers Technical Representative.

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USEPA Method 300.0. Inorganic Anions by Ion Chromatography.

Dissolved Gases: Ethane, Ethene, Methane, and Hydrogen in Groundwater. Robert S. Kerr Environmental Research Laboratory SOPs 147/175.

APPENDIX A

PROJECT-SPECIFIC HEALTH AND SAFETY PLAN

Health and Safety Plan

for

Additional Investigation Activities

at

Naval Weapons Station Earle

Site 13 (OU-5)

Colts Neck, New Jersey

Engineering Field Activity Northeast
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0851

August 2004

HEALTH AND SAFETY PLAN
FOR
ADDITIONAL INVESTIGATION ACTIVITIES
AT
NAVAL WEAPONS STATION EARLE
SITE 13 (OU-5)
COLTS NECK, NEW JERSEY

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:

Engineering Field Activity Northeast
Environmental Branch, Code 18
Naval Facilities Engineering Command
10 Industrial Highway, Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Submitted by:
TetraTech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220-2745

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0851

AUGUST 2004

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) provides practices and procedures for Tetra Tech NUS, Inc. (TtNUS) and subcontractor personnel engaged in additional environmental investigation activities at the Naval Weapons Station (NWS) Earle in Colts Neck, Monmouth County, New Jersey. This HASP must be used in conjunction with the TtNUS Health and Safety Guidance Manual. Both of these documents must be present at the site during the performance of site activities. The Guidance Manual provides detailed information pertaining to the HASP as well as applicable TtNUS Standard Operating Procedures (SOPs). This HASP and the contents of the Guidance Manual were developed to comply with the requirements stipulated in 29 CFR 1910.120 (Occupational Safety and Health Administration's [OSHA's] Hazardous Waste Operations and Emergency Response Standard); OSHA's Construction Industry Standards, 29 CFR 1926; and NWS Earle procedures and protocol, as they may apply.

This HASP has been developed using the latest available information regarding known or suspected chemical contaminants and potential physical hazards associated with the proposed work at the site. The HASP will be modified if new information becomes available. All changes to the HASP will be made with the approval of the TtNUS Project Health and Safety Officer (PHSO) and the TtNUS Health and Safety Manager (HSM). Requests for modifications to the HASP will be directed to the PHSO, who will determine if the changes are necessary. The PHSO will notify the Project Manager (PM), who will notify affected personnel of changes.

1.1 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines responsibility for site safety and health for TtNUS and subcontractor employees engaged in onsite activities. Personnel assigned to these positions will exercise the primary responsibility for onsite health and safety. These persons will be the primary point of contact for questions regarding the safety and health procedures and the selected control measures that are to be implemented for onsite activities.

- The TtNUS PM is responsible for the overall direction of health and safety for this project.
- The PHSO is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include:

  i. Providing information regarding site contaminants and physical hazards associated with the site.
  ii. Establishing air monitoring and decontamination procedures.
  iii. Assigning personal protective equipment (PPE) based on task and potential hazards.

iv. Determining emergency response procedures and emergency contacts.

v. Stipulating training requirements and reviewing appropriate training and medical surveillance certificates.

vi. Providing standard work practices to minimize potential injuries and exposures associated with hazardous waste work.

vii. Modify this HASP, as it becomes necessary.

- The TtNUS Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed Site Safety Officer (SSO). The FOL manages field activities, executes the Work Plan, and enforces safety procedures as applicable that plan.
- The SSO supports site activities by advising the FOL on aspects of health and safety onsite. These duties may include:

i. Coordinates health and safety activities with the FOL.

ii. Selects, applies, inspects, and maintains PPE.

iii. Establishes work zones and control points in areas of operation.

iv. Implements air monitoring program for onsite activities.

v. Verifies training and medical clearance of onsite personnel status in relation to site activities.

vi. Implements Hazard Communication, Respiratory Protection Programs, and other associated health and safety programs as they may apply to site activities.

vii. Coordinates emergency services.

viii. Provides site-specific training for onsite personnel.

ix. Investigates accidents and injuries (see Attachment I - Illness/Injury Reporting Procedure and Form)

x. Provides input to the PHSO regarding the need to modify, this HASP, or applicable health and safety associated documents as per site-specific requirements.

- Compliance with the requirements stipulated in this HASP is monitored by the SSO and coordinated through the TtNUS HSM.

1.2 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: NWS Earle
EFANE RPM: Michele DiGeambeardino
Site Contact: Alicia Harman

Address: 201Highway 34 South Colts Neck, NJ
Phone Number: (610) 595-0567 (Ext. 117)
Phone Number: (732) 866-2060

Scheduled Activities: Site activities that will be addressed in this HASP include geophysical, surveying, installation of monitoring wells via hollow stem auger techniques, and sampling of installed and existing wells to confirm the absence of contamination in groundwater at Site 13 (OU-5), and surveying activities. Further details on these and other site tasks are in Section 4 of this HASP.

Dates of scheduled activities: Site activities will begin in the Fall of 2004.

Project Team:

TtNUS Management Personnel:	Discipline/Tasks Assigned:
Daniel C. Witt, P.E.	Project Manager
TBA	Field Operations Leader (FOL)
TBA	Project Geologist
Matthew M. Soltis, CIH, CSP	Health and Safety Manager
Donald J. Westerhoff, CSP	Project Health and Safety Officer (PHSO)
TBA	Site Safety Officer (SSO)

Other Potential TtNUS Project Personnel:

Tom Patton	Equipment Manager

Non-TtNUS Personnel	Affiliation/Discipline/Tasks Assigned
TBA	Drilling contractor
TBA	Analytical Laboratory
TBA	Surveying contractor

Hazard Assessment (for purpose of 29 CFR 1910.132) for HASP preparation has been conducted by:
Donald J. Westerhoff, CSP

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section is to direct and guide field personnel in the event of an emergency. All site activities are coordinated with the client contacts. In the event of an onsite emergency, personnel will evacuate to a safe place of refuge and notify the NWS Earle Emergency Coordinator who is the Fire Chief. The NWS Earle emergency staff will coordinate on-site activities. They are the only authorized emergency responders who provide service in emergency situations. TtNUS and subcontractor personnel will notify the NWS Earle Emergency Dispatcher and only provide initial or incipient stage emergency response measures. Workers who are ill or who have suffered a non-serious injury may be transported by site personnel to nearby medical facilities, provided that such transport does not aggravate or further endanger the welfare of the injured or ill person. The NWS Earle emergency response agencies listed in this plan are fully capable of providing the most effective response, and as such, are designated as the primary responders. These agencies are located within a reasonable distance from the area of site operations, which ensures adequate emergency response time. The TtNUS Project Manager and HSM are to be notified in the event of an onsite incident. This Emergency Action Plan conforms to the requirements of 29 CFR 1910.38(a), as allowed in 29 CFR 1910.120(l)(1)(ii).

TtNUS will, through necessary services, provide the following emergency action measures:

- Incipient stage fire-fighting support and prevention
- Incipient spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Initial medical support for injuries or illnesses requiring basic first aid
- Site control and security measures as necessary

2.2 PRE-EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, emergencies resulting from chemical, physical, or fire hazards are the types of emergencies that could be encountered during site activities.

To minimize and eliminate the potential for these emergency situations, pre-emergency planning activities will include the following (which are the responsibility of the SSO and/or the FOL):

- Coordinating with local Emergency Response personnel to ensure that TtNUS emergency action activities are compatible with existing emergency response procedures. NWS Earle Fire Protection and Emergency Services will be notified about scheduled events and activities. This is most imperative in situations where their services may be required.
- Establishing and maintaining information at the project staging area (support zone) for easy access in the event of an emergency. This information will include the following:
  - Chemical inventory (of chemicals used onsite), with Material Safety Data Sheets (MSDSs).
  - Onsite personnel medical records (Medical Data Sheets).
  - A log book identifying personnel onsite each day.
  - Hospital route map with directions (these should also be placed in each site vehicle).
  - Emergency notification - phone numbers.

The TtNUS FOL will be responsible for the following tasks:

- Identifying a chain of command for emergency action.
- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible.
- Periodically performing practice drills to ensure site workers are familiar with incidental response measures.
- Providing the necessary equipment to safely accomplish identified tasks.

2.3 EMERGENCY RECOGNITION AND PREVENTION

2.3.1 Recognition

Emergency situations that may be encountered during site activities will generally be recognized by visual observation. Visual observation is primarily relevant for physical hazards that may be associated with the proposed scope of work. Visual observation will also play a role in detecting some chemical hazards. To adequately recognize chemical exposures, site personnel must have a clear knowledge of signs and symptoms of exposure associated with site contaminants. This information is provided in Table 6-1. Tasks to be performed at the site, potential hazards associated with those tasks, and the recommended control methods are discussed in detail in Sections 5.0 and 6.0. Additionally, early recognition of hazards will be supported by daily site surveys to eliminate a situation predisposed to an emergency. The FOL and/or the SSO will be responsible for performing surveys of work areas before initiating site operations and periodically while operations are being conducted. Findings will be documented by the FOL and/or the SSO in the Site Health and Safety logbook; however, site personnel will be responsible for reporting hazardous situations. Where potential hazards exist, TtNUS will initiate control measures to prevent adverse effects to human health and the environment.

The above actions will provide early recognition for potential emergency situations and allow TtNUS to initiate necessary control measures. However, if the FOL and the SSO determine that control measures are not sufficient to eliminate the hazard, TtNUS will withdraw from the site and notify the appropriate response agencies listed in Table 2-1.

2.3.2 Prevention

TtNUS and subcontractor personnel will minimize the potential for emergencies by following the Health and Safety Guidance Manual and ensuring compliance with the HASP and applicable OSHA regulations. Daily site surveys of the work areas will also assist in the prevention of illness/injuries by identifying potential hazards and initiating appropriate control measures. The FOL or SSO will conduct these surveys at the beginning of each workday.

2.4 EVACUATION ROUTES, PROCEDURES, AND PLACES OF REFUGE

An evacuation will be initiated whenever recommended hazard controls are insufficient to protect the health, safety, or welfare of site workers. Specific examples of conditions that may initiate an evacuation include, but are not limited to, the following: severe weather conditions; fire or explosion; monitoring instrumentation readings that indicate levels of contamination are greater than established action levels; and evidence of personnel overexposure to potential site contaminants.

In the event of an emergency requiring evacuation, personnel will immediately stop activities and report to the designated safe place of refuge unless doing so would pose additional risks. When evacuation to the primary place of refuge is not possible, personnel will proceed to a designated alternate location and remain until further notification from the TtNUS FOL. Other safe places of refuge will be identified before the commencement of site activities by the SSO and will be conveyed to personnel as part of the pre-activities training session. This information will be reiterated during daily safety meetings. Whenever possible, the safe place of refuge will also serve as the telephone communications point for that area. During an evacuation, personnel will remain at the refuge location until directed otherwise by the TtNUS FOL or the On-scene Incident Commander. The FOL or the SSO will perform a head count at this location to account for and to confirm the location of site personnel. Emergency response personnel will be immediately notified of unaccounted personnel. The SSO will document the names of personnel onsite (on a daily basis) in the site Health and Safety Logbook. This information will be used to perform the head count in the event of an emergency.

Evacuation procedures will be discussed during the pre-activities training session before the initiation of project tasks. Evacuation routes from the site and safe places of refuge are dependent on the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e., wind speed and direction) may dictate evacuation routes. As a result, assembly points will be selected and communicated to the workers relative to the site location where work is being performed. Evacuation should always take place in an upwind direction from the site.

2.5 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

TtNUS personnel will work in close proximity at NWS Earle. As a result, hand signals, voice commands, and line-of-site communication will be sufficient to alert site personnel of an emergency. When project tasks are performed simultaneously on different sites, cell phones or air/vehicle horns will be used to communicate emergency situations. If an emergency warranting evacuation occurs, the following procedures are to be initiated:

- Initiate the evacuation via hand signals, voice commands, line-of-site communication, cell phones or air/vehicle horns. The following signals shall be used when communication via air/vehicle horn is necessary:

HELP	three short blasts	▪ ▪ ▪
EVACUATION	three long blasts	▬ ▬ ▬

- Report to the designated refuge point.
- Once nonessential personnel are evacuated, appropriate response procedures will be enacted to control the situation.
- Give the FOL (FOL will serve as the Incident Coordinator) pertinent incident details.

TtNUS personnel will perform removal of personnel from emergency situations and may provide initial medical support for injuries/illnesses requiring only first aid level support. Medical attention above that level will require assistance and support form the designated emergency response agency. Attachment I provides the procedure to follow when reporting an injury/illness and the form to be used for this purpose. **If the emergency involves exposures to chemicals, follow the steps provided in Figure 2-2.**

In the event that site personnel cannot mitigate the hazardous situation, the FOL and/or SSO, will enact emergency notification procedures to secure additional assistance in the following manner:

Dial the NWS Earle Emergency Center immediately and then call other pertinent emergency contacts listed in Table 2-1 to report the incident. Give the emergency operator the location of the emergency, the type of emergency, the number of personnel injured, and a brief description of the incident. Stay on the phone and follow the instructions given by the operator. The operator will then notify and dispatch the proper emergency response agencies.

2.6 EMERGENCY CONTACTS

Before initiating field activities, personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted where it is readily available to site personnel. Facility maps should also be posted showing potential evacuation routes and designated meeting areas

TABLE 2-1

EMERGENCY REFERENCE
NWS EARLE, NEW JERSEY

CONTACT	PHONE NUMBER
Emergency Center: Police, Fire, Ambulance	**2911** or (732) 866-2911
Fire Department, NWS Earle	(732) 866-2333
Security, NWS Earle	(732) 866-2291
NWS Earle, UXO Support (Chief Winkle)	(732) 866-2009
Riverview Medical Center	(732) 741-2700
New Jersey Poison Control Center	(800) 962-1253
New Jersey One Call (Underground Utility Locator)	(800) 272-1000
National Response Center	(800) 424-8802
Chemtrec	(800) 424-9300
NWS Earle Base Contact – Alicia Hartman	(732) 866-2060
EFANE RPM – Michele DiGeambeardino	(610) 595-0567 ext. 117
TtNUS Project Manager – Dan Witt, P.E.	(412) 921- 8259
Health and Safety Manager - Matthew M. Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer – Donald J. Westerhoff, CSP	(412) 921-7281

2.7 EMERGENCY ROUTE TO HOSPITAL

Riverview Medical Center; 1 Riverview Plaza, Red Bank, New Jersey 07701

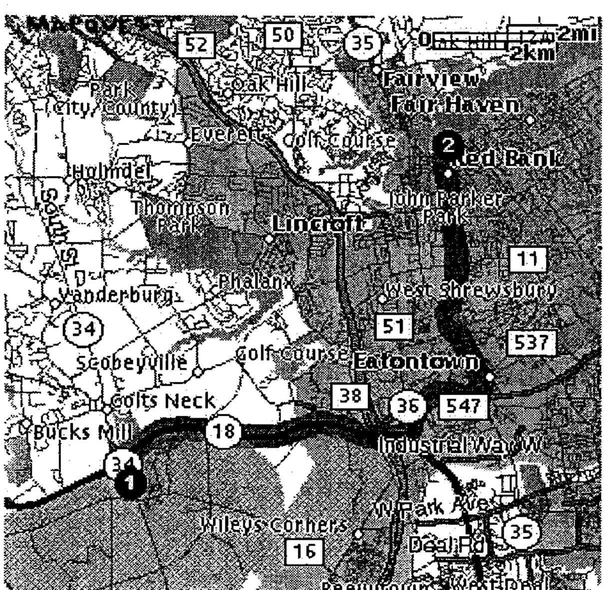
Directions from Mainside Base:

Turn Route 34 north to County Road ❶. At the "T" turn right onto Swimming River Road. Make a left onto Sycamore Avenue. In Shrewsbury, turn left on to Broad Street. Make a right onto Front Street and an immediate left onto Wharf Avenue. ❷The hospital is on the right.

FIGURE 2-1

ROUTE MAP FROM MAIN SIDE NWS EARLE TO RIVERSIDE MEDICAL CENTER

FULL ROUTE



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DESTINATION

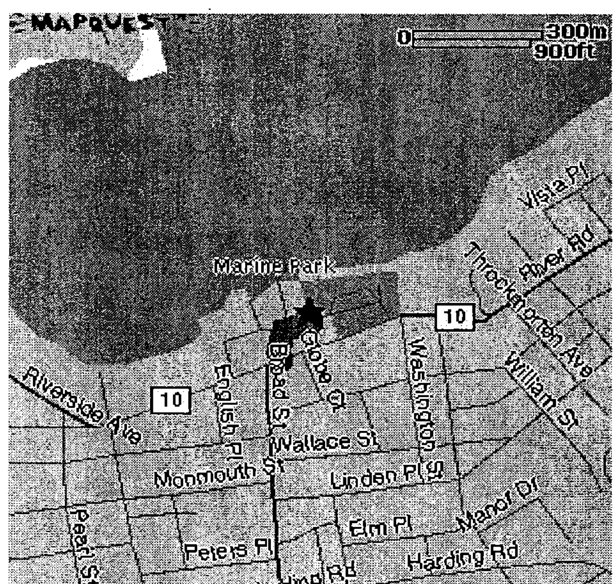

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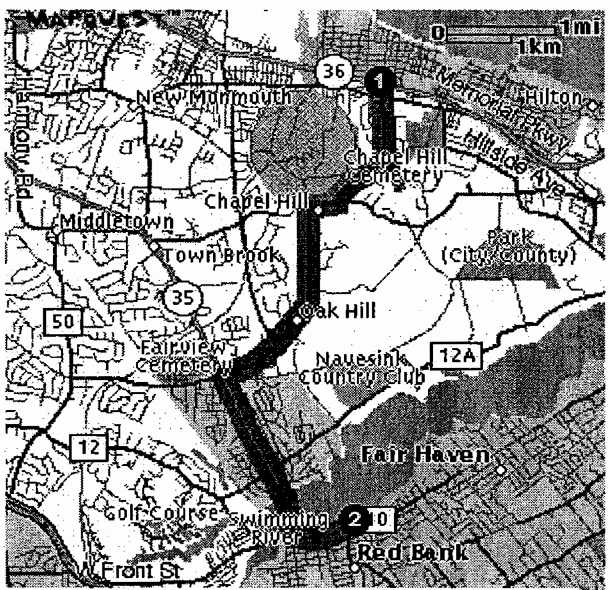
FIGURE 2-1A

ROUTE MAP FROM WATERFRONT NWS EARLE TO RIVERSIDE MEDICAL CENTER

Directions from the Waterfront:

Take Normandy Road south. ❶ Make the first left onto Sleepy Hollow Road. At the "T" turn right onto Chapel Hill Road. Turn left onto Route 35. After crossing Cooper's Bridge, make a left onto Front Street. After crossing Maple, take the second left onto Wharf Avenue. ❷ Riverview Hospital is on the right.

FULL ROUTE



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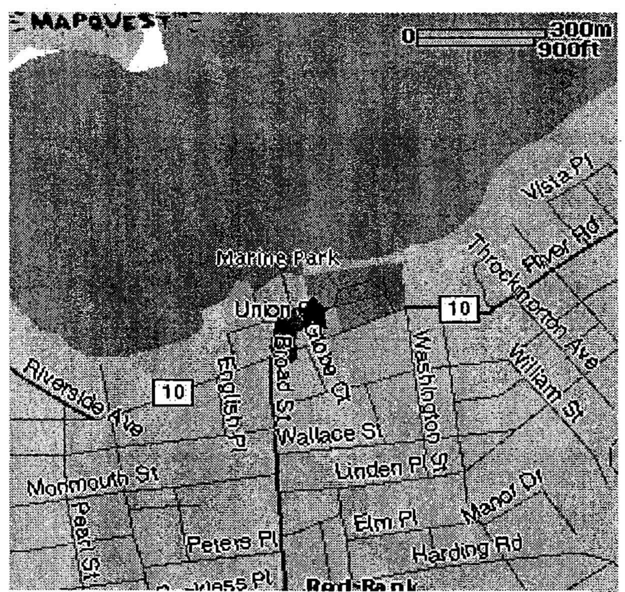
Destination



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2.8 DECONTAMINATION PROCEDURES / EMERGENCY MEDICAL TREATMENT

During a site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will not be performed if the incident warrants immediate evacuation. However, it is unlikely that an evacuation would occur that would require workers to evacuate the site without first performing the necessary decontamination procedures.

2.9 INJURY/ILLNESS REPORTING

If TtNUS personnel are injured or develop an illness as a result of working on site, the TtNUS "Injury/Illness Procedure" (Attachment I) must be followed. Following this procedure it is necessary for documenting the information obtained at the time of the incident.

Pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite. If an exposure to hazardous materials has occurred, provide information on the chemical, physical, and toxicological properties of the subject chemical(s) to medical service personnel.

2.10 PPE AND EMERGENCY EQUIPMENT

PPE normally available for the project will also be available for use in case of an emergency or spill incident.

A first aid kit, eye wash units, and fire extinguishers will be maintained on-site and shall be immediately available for use in case of an emergency.

**FIGURE 2-2
EMERGENCY RESPONSE PROTOCOL**

The purpose of this protocol is to provide guidance for the medical management of injury situations.

In the event of a personnel injury or accident:

- Rescue, when necessary, employing proper equipment and methods.
- Give attention to emergency health problems -- breathing, cardiac function, bleeding, and shock.
- Transfer the victim to the medical facility designated in this HASP by suitable and appropriate conveyance (i.e. ambulance for serious events)
- Obtain as much exposure history as possible (a Potential Exposure report is attached).
- If the injured person is a Tetra Tech NUS employee, call the medical facility and advise them that the patient(s) is/are being sent and that they can anticipate a call from the WorkCare physician. WorkCare will contact the medical facility and request specific testing which may be appropriate. WorkCare physicians will monitor the care of the victim. Site officers and personnel should not attempt to get this information, as this activity leads to confusion and misunderstanding.
- Call WorkCare at 1-800-455-6155 enter Extension 109, or follow the voice prompt for after hours and weekend notification, and be prepared to provide:
  - Any known information about the nature of the injury.
  - As much of the exposure history as was feasible to determine in the time allowed.
  - Name and phone number of the medical facility to which the victim(s) has/have been taken.
  - Name(s) of the involved Tetra Tech NUS, Inc. employee(s).
  - Name and phone number of an informed site officer who will be responsible for further investigations.
  - Fax appropriate information to WorkCare at (714) 456-2154.
- Contact Corporate Health and Safety Department (Matt Soltis) at 1-800-245-2730.
- Contact the Human Resources Manager (Marilyn Duffy) at 1-800-245-2730.

As data is gathered and the scenario becomes more clearly defined, this information should be forwarded to WorkCare.

WorkCare will compile the results of data and provide a summary report of the incident. A copy of this report will be placed in each victim's medical file in addition to being distributed to appropriately designated company officials.

Each involved worker will receive a letter describing the incident but deleting personal or individual comments. A personalized letter describing the individual findings/results will accompany this generalized summary. A copy of the personal letter will be filed in the continuing medical file maintained by WorkCare.

FIGURE 2-2 (continued)
WORKCARE

POTENTIAL EXPOSURE REPORT

Name: ______________________ Date of Exposure: __________

Social Security No.: ______________ Age: __________ Sex: ________

Client Contact: ______________________ Phone No.: __________

Company Name: ______________________________

I. Exposing Agent
Name of Product or Chemicals (if known):______________________
____

Characteristics (if the name is not known)
Solid Liquid Gas Fume Mist Vapor

II. Dose Determinants
What was individual doing?______________________
How long did individual work in area before signs/symptoms developed? __________
Was protective gear being used? If yes, what was the PPE? __________
Was their skin contact? ______________________
Was the exposing agent inhaled?______________________
Were other persons exposed? If yes, did they experience symptoms? __________

III. Signs and Symptoms (check off appropriate symptoms)

<u>Immediately With Exposure:</u>

Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Nausea / Vomiting
Dizziness
Weakness

<u>Delayed Symptoms:</u>

Weakness
Nausea / Vomiting
Shortness of Breath
Cough
Loss of Appetite
Abdominal Pain
Headache
Numbness / Tingling

IV. Present Status of Symptoms (check off appropriate symptoms)
Burning of eyes, nose, or throat
Tearing
Headache
Cough
Shortness of Breath
Chest Tightness / Pressure
Cyanosis
Nausea / Vomiting
Dizziness
Weakness
Loss of Appetite
Abdominal Pain
Numbness / Tingling

Have symptoms: (please check off appropriate response and give duration of symptoms)
Improved: ________ Worsened: ______ Remained Unchanged: ______

V. Treatment of Symptoms (check off appropriate response)
None: __________ Self-Medicated: ______ Physician Treated: ______

3.0 SITE BACKGROUND

3.1 SITE HISTORY AND LOCATION

The NWS Earle is located in the east-central coastal region of Monmouth County in Colts Neck, New Jersey, approximately 35 miles south of New York City and 70 miles northeast of Philadelphia. It is situated on approximately 11,134 acres and includes a Mainside area, which is approximately 10 miles inland from the Atlantic Ocean at Sandy Hook Bay, and a Waterfront area, which includes an ammunition depot and associated piers. The Mainside and Waterfront areas are linked by a narrow tract of land that serves as a right-of-way for a government road and railroad.

The main entrance to NWS Earle is located off State Route 34, and the entrance to the Waterfront area is located adjacent to State Route 36.

The majority of the land at the Mainside area is undeveloped land associated with ordnance operations, production, and storage facilities; the undeveloped land is encumbered by explosive safety quantity distance (ESQD) arcs. Land use at the Mainside facility includes residences, office buildings, workshops and warehouses, recreational areas, open space, and undeveloped land. The area around the Mainside facility includes agricultural areas, vacant land, and low-density residential land.

3.1.1 Site 13

Site 13 is located at least partially within ESQD arcs. Therefore, future development at this site is severely restricted. The DPDO Yard is an area of fill material extending into a marsh near the rail classification yards. Activities at the site included storage of scrap metals and batteries and the burial of material, such as cars, trucks, electronic equipment, clothing/shoes, sheet metal, furniture, scrap metal, and batteries. Additionally, batteries were broken open at the site for lead recovery, and acid was drained onto the ground. Since the primary function of this site was scrap metal storage, it is unlikely that any unexploded ordnance (UXO) would be present in the fill material, however, ordinance "shapes" have been encountered at this site during previous intrusive activities. Ordnance handling only occurs within specifically designated areas of NWS Earle. Obvious fill material is present at the ground surface at several places across the site. A partial removal of exposed debris was performed by NWS Earle public works employees in the summer of 1997.

NWS Earle is located in the coastal lowlands of Monmouth County, New Jersey, within the Atlantic Coastal Plain Physiographic Province. The Mainside area, which includes Site 13, lies in the outer Coastal Plain, approximately 10 miles inland from the Atlantic Ocean. The Mainside area is relatively flat, with elevations ranging from approximately 100 to 300 feet above mean sea level (MSL). The most significant topographic relief within the Mainside area is Hominy Hills, a northeast-southwest-trending group of low hills located near the center of NWS Earle.

4.0 SCOPE OF WORK

This section describes the project tasks that will be performed at NWS Earle. Additionally, each task has been evaluated and the associated hazards and recommended control measures are listed in Table 5-1 of this HASP. If new tasks are to be performed at the site, Table 5-1 and this section will be modified accordingly.

The following is a list of activities that are proposed for the investigation:

- Mobilization and demobilization – These tasks include the procurement and shipping of equipment and materials for the field investigation; review of planning documents; site reconnaissance (site characterization, site preparation, layout of sampling locations, obtaining necessary utility clearances, isolation physical hazards, etc.)
- Soil boring and groundwater sampling activities (using hollow stem auger techniques) – 10 monitoring wells will be installed in the wetland area to define the down gradient edge of contamination. It is anticipated that based on quick turnaround analysis of groundwater sampling results six of these wells will be kept and permanent caskings will be installed. The other 4 wells will be abandoned.
- Groundwater sampling of six existing monitoring wells
- Decontamination of sampling and heavy equipment – Heavy equipment (drill rig) will be cleaned and decontaminated with high-pressure wash (pressure washer). Sampling equipment (split spoon, trowels, etc.) will be decontaminated with soap (liquinox or equivalent) and water and allowed to air dry.
- Geographic Surveying – Ground surface topography, physical features, and point survey of the soil boring locations.

If additional tasks are determined to be necessary, this HASP will be amended and a hazard evaluation of the additional tasks will be performed.

5.0 TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES

Table 5-1 of this section serves as the primary portion of the site-specific HASP that identifies the tasks that are to be performed as part of the scope of work. This table will be modified and incorporated into this document as new or additional tasks are performed at the site. The anticipated hazards, recommended control measures, air-monitoring recommendations, required PPE, and decontamination measures for each site task are discussed in detail. This table and the associated control measures shall be changed if the scope of work, contaminants of concern, or other conditions change.

Through using the table, site personnel can determine which hazards are associated with each task and at each site, and what associated control measures are necessary to minimize potential exposure or injuries related to those hazards. The table also assists field team members in determining which PPE and decontamination procedures to use based on proper air monitoring techniques and site-specific conditions.

The TtNUS Health and Safety Guidance Manual supports this table and HASP. The guidance manual further explains supporting programs and elements for other site-specific aspects as required by 29 CFR 1910.120. The Guidance Manual should be referenced for additional information regarding air monitoring instrumentation, decontamination activities, emergency response, hazard assessments, hazard communication and hearing conservation programs, medical surveillance, PPE, respiratory protection, site control measures, standard work practices, and training requirements. Numerous TtNUS SOPs are also provided in the Guidance Manual.

Safe Work Permits issued for exclusion zone activities (See Section 10.10 and Attachment IV) will use elements defined in Table 5-1 as its primary reference. The FOL and/or the SSO completing the Safe Work Permit will add additional site-specific information. In situations in which the Safe Work Permit is more conservative than the direction provided in Table 5-1 due to the incorporation of site-specific elements, the Safe Work Permit will be followed. Attachment VI is the "Standard Operating Procedures for Unexploded Ordnance Avoidance Operations." Additional site-specific information will be added to the Safe Work Permit by the FOL and/or the SSO.

5.1 GENERAL SAFE WORK PRACTICES

In addition to the task-specific work practices identified on Table 5-1 general safe work practices should be followed when conducting work involving known and unknown site hazards. These safe work practices establish a pattern of general precautions and measures for reducing risks associated with hazardous site operations.

- Refrain from eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists.
- Wash hands and face thoroughly upon leaving a contaminated or suspected contaminated area. A thorough shower and washing must be conducted as soon as possible if excessive skin contamination occurs.
- Avoid contact with potentially contaminated substances by walking around puddles, pools, mud, or other such areas. Avoid, whenever possible, kneeling on the ground or leaning or sitting on equipment.
- Be aware of the location of the nearest telephone and the emergency telephone numbers. See Section 2.0, Table 2-1.
- Rehearse unfamiliar operations prior to implementation.
- Maintain visual contact with each other and with other on-site team members by remaining in close proximity in order to assist each other in case of emergency.
- Establish appropriate safety zones including support, contamination reduction, and exclusion zones.
- Minimize the number of personnel and equipment in contaminated areas (such as the exclusion zone). Non-essential vehicles and equipment should remain within the Support Zone.
- Establish appropriate decontamination procedures for leaving the site.
- Observe coworkers for signs of toxic exposure and heat stress. Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.
- Whenever possible, stand upwind from an operating drill rig.
- Establish hand signals with the drill rig operator.
- Work areas must be kept free of ground clutter.
- When in operation, personnel will remain more than three feet from the boom.

5.2 DRILLING OPERATIONS - SAFE WORK PRACTICES

The following Safe Work Practices are to be followed when working in or around drill rigs.

5.2.1 Before Drilling Operations

- Identify all underground utilities and buried structures before drilling. Use the Utility Locating and Excavation Clearance Standard Operating Procedure provided in Attachment II. See notes for the time lines required on and off-Base utility clearances under mobilization/demobilization Section 4.1.

- All drilling rigs will be inspected by the SSO (or designee), prior to the acceptance of the equipment at the site and prior to the use of the equipment. All repairs or deficiencies identified will be corrected prior to use. The inspection will be accomplished using the Equipment Inspection Checklist provided in Attachment III. Inspection frequencies will be once every 10 day shift or following repairs.

- The work area around the point of operation will be graded to the extent possible to remove any trip hazards near or surrounding operating equipment.

- The driller's helper will establish an equipment staging and lay-down plan. The purpose of this is to keep the work area clear of clutter and slips, trips, and fall hazards. Mechanisms to secure heavy objects such as auger flights will be provided to avoid the collapse stacked equipment.

- Potentially contaminated tooling will be wrapped in polyethylene sheeting for storage and transport to the centrally located decontamination unit.

5.2.2 During Drilling Operations

- Verbally alert workers and visually check to make sure personnel are away from moving parts or are in a safe location prior to starting drilling operations.

- Assign one individual (drill rig operator) who is responsible for manning the emergency shut off device at all times and communicate this person to the entire field crew,

- Minimize contact to the extent possible with contaminated tooling and environmental media.

- Support functions (sampling and screening stations) will be maintained a minimum distance from the drilling rig of the height of the mast plus five feet to remove these activities from within physical hazard boundaries.

- Only qualified operators and knowledgeable ground crew personnel will participate in the operation of the drill rig. All drill rig operators will be instructed in the location and operation of emergency stop buttons, switches or other devices and these shall in good operating condition and inspected daily.

- In order to minimize contact with potentially contaminated tooling and media and to minimize lifting hazards, multiple personnel should move heavy tooling, where necessary.

- Only personnel absolutely essential to the work activity will be allowed in the exclusion zone. Site visitors will be escorted at all times.

5.2.3 After Drilling Operations

- All equipment used within the exclusion zone will undergo a complete decontamination and evaluation by the SSO to determined cleanliness prior to moving to the next location, exiting the site, or prior to down time for maintenance.

- All motorized equipment will be fueled prior to the commencement of the day's activities. During fueling operations all equipment will be shutdown and bonded to the fuel provider.

- When not in use all drill rigs will be shutdown, emergency brakes set, and wheels chocked.

- All areas subjected to subsurface investigative methods will be restored to equal or better condition than original to remove any contamination brought to the surface and to remove any physical hazards. In situations where these hazards cannot be removed these areas will be barricaded to minimize the impact on field crews working in the area.

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring Type/Action Levels	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions dictate.*	Decontamination Procedures
Mobilization/ Demobilization	***Chemical hazards:*** 1) Exposure to potential site contaminants is not anticipated during this activity. However, chemicals brought on site in support of field activities are to be identified, logged, accompanied by an appropriate MSDS, properly stored, and evaluated for purposes of hazard communication. ***Physical hazards:*** Potential physical hazards associated with this task may include: 2) Lifting (muscle strains and pulls) 3) Pinches and compressions 4) Slip, trips, and falls 5) Vehicular and foot traffic	***Chemical hazards:*** 1) To eliminate potential chemical hazards associated with this task ensure the following: - A chemical inventory list is generated for all chemicals brought on site (Complete Section 5.0 of the Health and Safety Guidance Manual). - Material Safety Data Sheets must be available for all chemicals brought on site (Complete Section 5.0 of the Health and Safety Guidance Manual). - Materials are stored in accordance with recommended practices and according to compatibility (See MSDS for storage and compatibility recommendations). ***Physical hazards:*** 2) Use machinery or multiple personnel for heavy lifts. - Use proper lifting techniques. 3) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points. 4) Preview and prepare work locations where unstable/uneven terrain exists. 5) Identify all access/egress routes and locations to within established areas of operation. - All equipment capable of self-propelled movement will be equipped with movement alarms as applicable. - Traffic regulations for NWS Earle are to be followed as posted.	Not required during mobilization/demobilization.	Mobilization/demobilization activities is intended to initiate and proceed in Level D protection: Level D - (Minimum Requirements) - Standard field attire (Sleeved shirt; long pants; or coveralls) - Safety shoes or boots with steel toe - Safety glasses - *Hardhat (when overhead hazards exists, or identified as an operation requirement)* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario. As a general rule of thumb, if you need to raise your voice to be heard while engaged in conversation with someone who is within 2 feet of your position, you may be exposed to excessive noise levels and should use hearing protection.* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	As potential site contaminants are not anticipated as part of this task, personal decontamination is not required. All equipment arriving/leaving the site will be inspected prior to permitting this equipment to enter or exit the site. The SSO will inspect the equipment and give the clearance to allow the equipment to pass. Failure to pass inspection will prohibit entering or exiting the site as applicable. All equipment that fails the inspection will have to be decontaminated again to a level acceptable to the SSO prior to passage on or off site. All equipment permitted to pass on/off site will be documented using an Equipment Inspection Checklist. This form may be found in Attachment III of this HASP.

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring Type/Action Levels	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions dictate.*	Decontamination Procedures
Groundwater sampling activities	***Chemical hazards:*** 1) Previous analytical data identified various contaminants of concern including chloroform and methylene chloride and various metals in groundwater at Site 13. Metals, PCBs, various pesticides and VOCs (primarily chlorinated solvents and associated degradation products) have been detected in adjacent areas in sediments and surface waters, and these areas are to avoided to the greatest extent possible. None of the contaminants of concern have been previously detected at concentrations that are likely to present an inhalation exposure hazard to site personnel. It should be noted that historical information on Site 13 suggests that some potential exists for encountering lead and battery acids (from previous disposal practices). Further information on some of the primary contaminants of concern is presented in Figure 6-1. 2) Transfer of contaminants into clean areas or onto persons ***Physical hazards:*** 3) Lifting (muscle strains and pulls) 4) Pinches and compressions 5) Slip, trips, and falls 6) Noise hazards ***Natural hazards:*** 7) Temperature extremes 8) Insect/animal bites and stings 9) Inclement weather	***Chemical hazards:*** 1) Use real-time monitoring instrumentation, action levels, and identified PPE to identify, quantify, and control exposures to potentially contaminated media (e.g., air, water, soils). 2) Restrict the cross-use of equipment and supplies between sampling locations without first going through a suitable decontamination. ***Physical hazards:*** 3) Use machinery or multiple personnel for heavy lifts. Use proper lifting techniques. 4) Keep any machine guarding in place. Avoid moving parts. Use tools or equipment where necessary to avoid contacting pinch points. - A remote sampling device must be used to sample drill cuttings near rotating tools. The equipment operator shall shutdown machinery if the sampler is near moving machinery parts. 5) Preview work locations for unstable/uneven terrain. 6) Use hearing protection when working in the vicinity of operating equipment or other noise producing equipment. ***Natural hazards:*** 7) Personnel must be aware of the conditions of heat/cold stress and take appropriate preventive measures to prevent the illness. For example, drink caffeine-free liquids to replace body fluids lost as a result of sweating if working under hot conditions, take rest breaks in appropriate areas (shaded if conditions are hot, and warm break areas if conditions are cold). See Section 4 of the Tetra Tech NUS Health and Safety Guidance Manual for additional information on heat stress and cold stress. 8) Avoid nesting areas; Tape pant legs to work boots when in high brush (knee high) (tick hazards); Use repellents – follow manufacturer instructions. Apply Permonone over clothing articles to avoid skin irritation. Apply repellants containing DEET to skin areas. Application of repellants should concentrate where ticks and other insects will gain entry. Pant to boots, shirt to pants, collar; Perform close body inspections upon exiting high brush areas to facilitate and remove ticks and other insects; Report potential hazards to the SSO. Follow guidance presented in Section 4.0 of the TtNUS Health and Safety Guidance Manual and Section 6.3 of this HASP. 9) All operations will be temporarily suspended during inclement weather (e.g., electrical storms, high winds, etc.) at SSO's discretion.	**VOCs** **None of the contaminants of concern are anticipated to be present at detectable airborne concentrations. As a result, the contaminants of concern are unlikely to present a significant exposure potential to site workers, particularly via inhalation.** However, as a precautionary measure, either an FID or a PID (with an 11.3 eV or higher lamp strength) will be used as follows: 1) Screen potential source areas (excavated soils) to detect the presence of any VOCs. Elevated readings at a source area will require: Worker breathing zones to be monitored to determine airborne concentrations of VOCs that may oppose an inhalation hazard to site workers. Any sustained (> 1 minute in duration) airborne concentration greater than 5.0 ppm in a worker breathing zone requires site activities to be suspended and notification of the PHSO. **Dusts/Particulates** Observations of visible dust (approximately 2 mg/m^3) will require site personnel to employ dust suppression (area wetting) methods if airborne dusts cannot be otherwise avoided by moving site operations upwind or by repositioning site equipment away from visible dust clouds. This conservative action level will control potential exposures to all site contaminants and nuisance particulates.	All sampling activities are anticipated to proceed in Level D protection as specified below: Level D - (Minimum Requirements) For sampling activities: - Standard field attire (Sleeved shirt; long pants) - Safety shoes or boots (Steel toe) - Safety glasses with side shields - Nitrile gloves (Clean pair for each sample location), layered if necessary - *Hard-hat (when overhead hazards exists such as when working around heavy equipment, or as identified as an operation requirement)* - *Reflective vest for high traffic areas or when working around heavy equipment* - *Hearing protection for high noise areas, or as directed on an operation by operation scenario.* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	Decontaminate sample containers in accordance with the Field Sampling Plan / Work Plan. **Personnel decontamination:** - Equipment drop-off - Wash and rinse reusable outer protective garments (if applicable) - Remove and dispose of disposable PPE - Wash hands and face, leave contamination reduction zone. **Equipment decontamination:** See Task - Decontamination of Sampling and Heavy Equipment

TABLE 5-1
TASKS/HAZARDS/CONTROL MEASURES
NWS EARLE, COLTS NECK, NEW JERSEY

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring/Type and Action Level	Personal Protective Equipment *Italicize text is optional equipment to be worn as conditions require.*	Decontamination Procedures
Soil Borings Soil boring activities will be performed using hollow stem auger techniques.	***Chemical hazards:*** 1) Previous analytical data identified the presence of chloroform and methylene chloride in low concentrations in groundwater at Site 13. However, these contaminants are not likely to be present in airborne concentrations that would present an inhalation exposure hazard to site personnel. It should be noted that historical information on Site 13 suggests that the potential exists for encountering lead and battery acids (from previous disposal practices). Further information on some of the primary contaminants of concern is presented in Figure 6-1. 2) Transfer of contamination into clean areas or onto clean persons. ***Physical hazards:*** 3) Rotating machinery (entanglement) 4) Noise 5) Energized systems 6) Slips, trips, and falls 7) Pinch/compression 8) Ambient Temperature Extremes ***Natural hazards:*** 9) Natural hazards (Insect/animal bites and stings) 10) Inclement weather	***Chemical hazards:*** 1) Use real-time monitoring instrumentation, action levels, identified PPE, and work practices to control exposures to potentially contaminated media (air, water, soils, etc.). 2) Decontaminate all equipment and supplies between borings and prior to leaving the site. ***Physical hazards:*** 3) All equipment to be used will be - Inspected in accordance with Federal safety and transportation guidelines, OSHA (1926.600.601.602), and manufacturer's design. All inspections will be documented using the Equipment Inspection Checklist found in Attachment III of this HASP. - Operated and supported by knowledgeable operators, and ground crew. - Used within safe work zones, with routes of approach clearly demarcated. All personnel not directly supporting this operation will remain at least 25 feet from the point of operation. This will be the area identified as the exclusion zone. In addition to equipment considerations, the following safe operating procedures will be incorporated: - Hydraulic masts or other projecting devices shall be at least 20 feet from overhead power sources and a minimum of 3 feet from underground utilities. - Hand signals will be established prior to the commencement of the operation. - Only manufacturer-approved equipment may be used in conjunction with equipment repair procedures (e.g., flight connectors). - Work areas will be kept clear of clutter. - Secure all loose articles to avoid possible entanglement during coring activities. - All self-propelled equipment shall be equipped with movement warning systems. - All personnel will be instructed in the location and operations of the emergency shut-off device(s). This device will be tested initially (and then periodically) to ensure its operational status. - Areas will be inspected prior to the movement of the drill rig and support vehicles to eliminate any physical hazards. This will be the responsibility of the FOL and/or SSO. - The drill rig and support vehicles will be moved no closer than 3 feet to unsupported side-walls of excavations and embankments. 4) Hearing protection will be used during all drill rig intrusive activities. 5) All utility clearances shall be obtained prior to any subsurface investigation. Prior to any subsurface investigations, the locations of all underground utilities will be identified and marked. Follow the guidelines established in Attachment II (Utility Locating and Excavation Clearance SOP). The FOL will obtain written permit clearance prior to all subsurface investigations. 6) Preview and prepare work locations where unstable/uneven terrain exists. 7) Keep machine guards in place. Avoid moving parts. Secure long clothing, hair, or jewelry that could be entangled. 8) Personnel must be aware of the conditions of heat/cold stress and take appropriate preventive measures to prevent the illness. For example, drink caffeine-free liquids to replace body fluids lost in sweating if working under hot conditions, take rest breaks in appropriate areas (shaded if conditions are hot, and warm break areas if conditions are cold). See Section 4 of the Tetra Tech NUS Health and Safety Guidance Manual for additional information on heat stress and cold stress. ***Natural hazards:*** 9) This activity may take place in remote locations where natural hazards are a concern. To control this hazard: - Preview all work areas to remove or barricade physical hazards or potential nesting areas. - Clear sufficient area around the drill rig to permit unimpeded work. - See Groundwater sampling task for direction on measures to minimize potentials for insect bites (see also Attachment VI, Tick Control and Lyme Disease). 10) All operations will be temporarily suspended during electrical storms or other hazardous weather conditions at the SSO's discretion.	**VOCs** **None of the contaminants of concern are anticipated to be present at detectable airborne concentrations. As a result, the contaminants of concern are unlikely to present a significant exposure potential to site workers, particularly via inhalation.** However, as a precautionary measure, either an FID or a PID (with an 11.3 eV or higher lamp strength) will be used as follows: 1) Screen potential source areas (excavated soils) to detect the presence of any VOCs. Elevated readings at a source area will require: Worker breathing zones to be monitored to determine airborne concentrations of VOCs that may oppose an inhalation hazard to site workers. Any sustained (> 1 minute in duration) airborne concentration greater than 5.0 ppm in a worker breathing zone requires site activities to be suspended and notification of the PHSO. **Dusts/Particulates** Observations of visible dust (approximately 2 mg/m^3) will require site personnel to employ dust suppression (area wetting) methods if airborne dusts cannot be otherwise avoided by moving site operations upwind or by repositioning site equipment away from visible dust clouds. This conservative action level will control potential exposures to all site contaminants and nuisance particulates. Where the utility clearance cannot be determined, subsurface activities shall proceed with extreme caution using hand digging to at least below the frost-line depth (no less than 4 ft. BGS). Also, a magnetometer must be used for periodic down-hole surveys every 2 feet to a depth of at least 10 feet.	All soil boring operations are to be initiated in Level D protection. Level D protection constitutes the following minimum protection - Standard field dress (long pants, sleeved shirts) - Steel-toe safety shoes or boots - Nitrile gloves - Hard-hat, safety glasses, and earplugs or muffs. *- Tyvek coveralls will be worn if there is a possibility of soiling work attire.* *- Rubber boots for muddy conditions* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** - Will consist of a soap/water wash and rinse for outer protective equipment (e.g. boots, gloves, etc.). This function will take place at an area adjacent to the drilling operations bordering the support zone. This decontamination procedure for Level D protection will consist of - Equipment drop - Remove and dispose of any disposable PPE (Tyvek coveralls, outer gloves, etc.) - Soap/water wash and rinse of reusable PPE items (e.g., boots). - Wash hands and face; leave contamination reduction zone **Equipment Decontamination** - All heavy equipment decontamination will take place at Site 13 utilizing steam or pressure washers. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will be restricted access to exclusion zones, or also have their wheels/tires sprayed off so as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible for evaluating equipment arriving on site and prior to leaving the site. No equipment will be authorized access or exit without this inspection and authorization. See Attachment III Equipment Inspection Checklist.

Tasks/Operation/ Locations	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring/Type and Action Levels	Personal Protective Equipment *Italicize text represents optional equipment to be worn when conditions dictate.*	Decontamination Procedures
Surveying activities.	***Chemical hazards:*** **Exposure to potential site contaminants during surveying activities is unlikely given the nature of the work and the limited contact with potentially contaminated media (soils, sediments, surface water, etc.). To further reduce the potential for exposure, site personnel performing these activities will minimize contact with potentially contaminated media and will avoid areas where chemical hazards may exist.** Previous analytical data identified various contaminants of concern including chloroform and methylene chloride in groundwater, and metals, PCBs, various pesticides and VOCs in sediments and surface water. However, none of the contaminants of concern were previously detected at concentrations that are likely to present an inhalation exposure hazard to site personnel. It should be noted that historical information on Site 13 suggests that the potential exists for encountering lead and battery acids (from previous disposal practices). ***Physical hazards:*** 1) Slip, trips, and falls ***Natural hazards:*** 2) Insect/animal bites and stings, poisonous plants 3) Inclement weather 4) Ambient Temperature Extremes	1) Preview work locations and site lines for uneven and unstable terrain. Clear necessary vegetation and establish temporary means for traversing hazardous terrain (e.g. rope ladders). ***Natural hazards:*** 2) Avoid potential nesting areas of biting/stinging insects and animals. Use commercially available insect repellents (Permanone on clothing and DEET on skin). Avoid contact with poisonous vegetation. Wear appropriate clothing. Tape ankle and wrists areas to prevent ticks, chiggers, etc. from attaching themselves to your skin. Wear light-colored clothing so that ticks and other biting insects can be easily visible and be removed. Follow directions as specified in section 6.2 concerning natural hazards. 3) All operations will be temporarily suspended during electrical storms. 4) Personnel must be aware of the conditions of heat/cold stress and take appropriate preventive measures to prevent the illness. For example, drink caffeine-free liquids to replace body fluids lost in sweating if working under hot conditions, take rest breaks in appropriate areas (shaded if conditions are hot, and warm break areas if conditions are cold). See Section 4 of the Tetra Tech NUS Health and Safety Guidance Manual for additional information on heat stress and cold stress.	No air monitoring is needed given that volatile contaminants are not likely to be present during these site activities. The potential for exposure to site contaminants during this activity is considered minimal.	Surveying activities shall be performed in Level D protection Level D Protection consists of the following: - Standard field dress including sleeved shirt and long pants - Steel-toe work boots or shoes - *Safety glasses, hard hats (if working near machinery or when eye/overhead hazards are present)* - *Tyvek coveralls may be worn to provide additional protection against poisonous plants and insects, particularly ticks.* - *Work gloves may be worn if desired.* - *Snake chaps for heavily wooded area where encounters are likely.* **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	Personnel Decontamination - A structured decontamination is not required, as the likelihood of encountering contaminated media is considered remote. However, survey parties should inspect themselves and one another for the presence of ticks when exiting wooded areas, grassy fields, etc. This action will be used to stop the transfer of these insects into vehicles, homes, and offices.

Task/Operation/ Location	Anticipated Hazards	Recommended Control Measures	Hazard Monitoring/Type and Action Levels	Personal Protective Equipment	Decontamination Procedures
Decontamination of Sampling and Heavy Equipment	*Chemical Hazards* 1) Previous analytical data identified various contaminants of concern including chloroform and methylene chloride in groundwater, and metals, PCBs, various pesticides and VOCs in sediments and surface waters. However, none of the contaminants of concern were previously detected at concentrations that are likely to present an inhalation exposure hazard to site personnel. It should be noted that historical information on Site 13 suggests that the potential exists for encountering lead and battery acids (from previous disposal practices). Further information on some of the primary contaminants of concern is presented in Figure 6-1. 2) Decontamination fluids - Liquinox (detergent), acetone or isopropanol *Physical Hazards* 3) Lifting (strain/muscle pulls) 4) Noise in excess of 85 dBA 5) Flying projectiles 6) Vehicular and foot traffic 7) Slips, trips, and falls *Natural Hazards* 8) Ambient temperature extremes (heat stress) 9) Inclement weather 10) Insect/animal bites and stings, poisonous plants	1) and 2) Use protective equipment to minimize contact with site contaminants and hazardous decontamination fluids. Obtain manufacturer's MSDS for any decontamination fluids used onsite. These must be used in well-ventilated areas, such as outdoors. Use appropriate PPE as identified on MSDS. All chemicals used must be listed on the Chemical Inventory for the site, and site activities must be consistent with the Hazard Communication section of the Health and Safety Guidance Manual (Section 5). ***Physical hazards:*** 3) Use multiple persons where necessary for lifting and handling sampling equipment for decontamination purposes. 4) Wear hearing protection when operating pressure washer. 5) Use eye and face protective equipment when operating pressure washer. All other personnel must be restricted from the area. 6) Traffic and equipment considerations are to include the following: - Establish safe zones of approach. - All equipment shall be equipped with movement warning systems. - All activities are to be conducted consistent with the Base requirements. 7) Preview work locations for unstable/uneven terrain. ***Natural hazards:*** 8) Personnel must be aware of the conditions of heat/cold stress and take appropriate preventive measures to prevent the illness. For example, drink caffeine-free liquids to replace body fluids lost in sweating if working under hot conditions, take rest breaks in appropriate areas (shaded if conditions are hot, and warm break areas if conditions are cold). See Section 4 of the Tetra Tech NUS Health and Safety Guidance Manual for additional information on heat stress and cold stress. 9) Suspend or terminate operations until directed otherwise by SSO. 10) Avoid nesting areas; Tape pant legs to work boots when in high brush (knee high) (tick hazards); Use repellents – follow manufacturer instructions. Apply Permonone over clothing articles to avoid skin irritation. Apply repellants containing DEET to skin areas. Application of repellants should concentrate where ticks and other insects will gain entry. Pant to boots, shirt to pants, collar; Perform close body inspections upon exiting high brush areas to facilitate and remove ticks and other insects.	Use visual observation, and real-time monitoring instrumentation to ensure all equipment has been properly cleaned of contamination and dried. After decon is completed, screen equipment with an FID or a PID. If any elevated readings (i.e., above background) are observed, perform decon again and re-screen. Repeat until no elevated FID/PID readings are noted.	*Italicized text represent optional equipment to be worn as conditions dictate.* For Heavy Equipment This applies to high-pressure soap/water, steam cleaning wash and rinse procedures. Level D Minimum requirements - - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Nitrile outer gloves - Safety glasses underneath a splash shield - Hearing protection (plugs or muffs) - *PVC Rainsuits or PE or PVC coated Tyvek* - *Chemical resistant boot covers* - *Hard hat (at SSO's discretion)* For sampling equipment the following PPE is required Note: Consult MSDS for PPE guidance. Otherwise, observe the following. Level D Minimum requirements - - Standard field attire (Long sleeve shirt; long pants) - Safety shoes (Steel toe/shank) - Nitrile outer gloves - Safety glasses In the event of overspray of chemical decontamination fluid use PVC Rainsuits or PE or PVC coated Tyvek as necessary. **Note:** The Safe Work Permit(s) for this task (see Attachment IV) will be issued at the beginning of each day to address the tasks planned for that day. As part of this task, additional PPE may be assigned to reflect site-specific conditions or special considerations or conditions associated with any identified task.	**Personnel Decontamination** will consist of a soap/water wash and rinse for reusable outer protective equipment (boots, gloves, PVC splash suits, as applicable). The decontamination function will take place at an area adjacent to the site activities. This procedure will consist of: - Equipment drop - Soap/water wash and rinse of outer boots and gloves, as applicable - Soap/water wash and rinse of the outer splash suit, as applicable - Disposable PPE will be removed and bagged. **Equipment Decontamination** - All heavy equipment decontamination will take place at a centralized decontamination pad utilizing steam or pressure washers. Heavy equipment will have the wheels and tires cleaned along with any loose debris removed, prior to transporting to the central decontamination area. All site vehicles will have restricted access to exclusion zones, and have their wheels/tires sprayed off as not to track mud onto the roadways servicing this installation. Roadways shall be cleared of any debris resulting from the onsite activity. **Sampling Equipment Decontamination** Sampling equipment will be decontaminated as per the requirements in the Sampling and Analysis Plan and/or Work Plan. MSDS for any decon solutions (Alconox, isopropanol, etc.) will be obtained and used to determine proper handling / disposal methods and protective measures (PPE, first-aid, etc.). All equipment used in the exclusion zone will require a complete decontamination between locations and prior to removal from the site. The FOL or the SSO will be responsible to evaluate equipment as it arrives and leaves the site. No equipment will be authorized access or exit without this evaluation. See Attachment III Equipment Inspection Checklist.

6.0 HAZARD ASSESSMENT

The following section provides information regarding the chemical, physical, and natural hazards anticipated to be present during the activities to be conducted. Table 6-1 provides information related to chemical constituents that have been identified by analysis or are suspected to be present at the site based on historical data. Specifically, toxicological information, exposure limits, symptoms of exposure, physical properties, and air monitoring and sampling data are discussed in the table.

6.1 CHEMICAL HAZARDS

Previous analytical data from Site 13 indicated the presence of various contaminants of concern including various metals, polychlorinated biphenyls (PCBs), an assortment of pesticides, and several volatile organic compounds (VOCs) primarily in the form of chlorinated solvents and associated degradation products. The most recent data available pertinent to groundwater at Site 13 indicate the presence of only two organic compounds: methylene chloride and chloroform. An evaluation of that data indicate that **it is very unlikely that personnel participating in drilling and sampling activities could encounter concentrations of any substances that would represent an exposure concern via inhalation**. Some limited potential exposure concerns could exist through direct skin contact or ingestion of contaminated media.

Potential routes of exposure through ingestion and skin contact will be minimized through the use of personal protective equipment (PPE), decontamination procedures, and good personal hygiene (washing hands prior to performing hand to mouth activities such as eating, smoking, etc.). As a precautionary measure, real-time monitoring instruments (flame ionization detector or photoionization detector) will be used to monitor for the presence of airborne concentrations of VOCs. Additionally, site personnel will visually monitor drilling operations to determine the presence of airborne dusts. If airborne dusts are observed, area wetting methods will be used to suppress the generation of dusts that may facilitate exposure through inhalation of airborne dusts. Table 6-1 provides information on the toxicological, chemical, and physical properties of some of the contaminants of concern.

TABLE 6-1

CHEMICAL, PHYSICAL, AND TOXICOLOGICAL DATA
SITE 13 NWS EARLE, COLTS NECK, NEW JERSEY

Substance	CAS No.	Air Monitoring/Sampling Information		Exposure Limits	Warning Property Rating	Physical Properties	Health Hazard Information
Chloroform	67-66-3	PID: I.P. 11.42 eV, relative response ratio unknown. FID: 100% response with FID	Air sample using charcoal sorbent tube and carbon disulfide desorption with gas chromatography flame ionization detector; Sample and analytical protocol in accordance with NIOSH Method #1003.	OSHA: 50 ppm (ceiling) NIOSH: STEL 2 ppm ACGIH: 10 ppm IDLH: 500 ppm	Inadequate - Odor threshold 133 - 276 ppm. Chloroform has poor warning properties but will adhere to organic vapor cartridges. Supplied air respirators are recommended. **Recommended glove:** Polyvinyl Alcohol >8.00 hrs; Viton 9.50 hrs; Teflon >3.60 hrs	**Boiling Pt:** 143°F; 62°C **Melting Pt:** -81°F; -62°C **Solubility:** 0.5% **Flash Pt:** N/A **LEL/LFL:** Not available **UEL/UFL:** Not available **Vapor Density:** Not available **Vapor Pressure:** 160 mmHg @ 68°F; 20°C **Specific Gravity:** 1.48 **Incompatibilities:** Strong caustics, chemically active metals such as aluminum or magnesium powder, sodium and potassium, strong oxidizers **Appearance and Odor:** Colorless liquid with a sweet pleasant odor.	Overexposure to this substance may cause dizziness, mental dullness, nausea, headache, fatigue, anaesthesia, and irritation of the skin and eyes. Chronic overexposure may result in damage to the liver, kidneys, heart, eyes and skin.
Methylene chloride	75-09-2	PID: I.P. 11.32 eV, High response with PID and 11.7 eV lamp. FID: 100% response with FID.	Air sample using charcoal or Anasorb CMS sorbent tube; carbon disulfide desorption; gas chromatography-flame ionization detector; Sampling and analytical protocol shall proceed in accordance with OSHA Method #59, 80, or NIOSH Method #1005.	OSHA: 50 ppm, 100 ppm (Ceiling) ACGIH: 50 ppm NIOSH: Lowest feasible concentration IDLH: 2300 ppm	Inadequate - Odor threshold 160 ppm. Use a gas mask with a Type N canister for concentrations up to 25 ppm. In excess of 25 ppm, use a supplied air respirator (airline respirator with emergency escape cylinder or a Self-Contained Breathing Apparatus - (SCBA). **Recommended gloves:** Nitrile rubber latex glove 3.00 hrs (vendor specific); supported Polyvinyl alcohol glove, unsupported 1-8 hrs; Silver shield 1.90 hrs	**Boiling Pt:** 104°F; 39.8°C **Melting Pt:** -141°F; -96°C **Solubility:** 2% **Flash Pt:** Not available **LEL/LFL:** 13% **UEL/UFL:** 12% **Vapor Density:** 2.93 **Vapor Pressure:** 380 mmHg @ 72°F; 22°C **Specific Gravity:** 1.33 **Incompatibilities:** Strong oxidizers, caustics, metals (i.e. aluminum, magnesium, potassium, sodium, lithium), and concentrated acids **Appearance and Odor:** Colorless liquid with a chloroform-like odor. (Note: A gas above 104°F; 40°C).	Effects of overexposure may include CNS effects - cause sleepiness, fatigue, weakness, lightheadedness, numbness of the limbs, altered cardiac rate and incoordination. These signs and symptoms may be accompanied by nausea, gastric and pulmonary irritation leading possibly to pulmonary edema. In addition to the narcosis long term effects may include liver injury. Listed as possessing carcinogenic properties by NTP, IARC, and ACGIH.

6.2 PHYSICAL HAZARDS

The physical hazards that may be present during the performance of site activities are summarized below:

- Heavy equipment hazards (pinch/compression points, rotating equipment, etc.)
- Slips, trips, and falls
- Energized systems (contact with underground or overhead utilities)
- Lifting (strain/muscle pulls)
- Noise exceeding 85 decibels (dBAs)
- Ambient temperature extremes (heat or cold stress)
- Eye (flying projectiles) and foot hazards
- Pinches and compressions
- Contact with sharp objects (glass, metal, etc.)
- Vehicular and foot traffic

These physical hazards are discussed in Table 5-1 as applicable to each site task. Furthermore, many of these hazards are discussed in detail in Section 4.0 of the Health and Safety Guidance Manual. Specific discussion on some of these hazards is presented below.

6.2.1 Heavy Equipment Hazards (Pinch/Compression Points, Rotating Equipment, etc.)

Often the hazards associated with drilling operations are the most dangerous to be encountered during site activities. The SSO will thoroughly discuss safe drilling procedures during the pre-activities training session. All site personnel will sign the form in Figure 8-2 documenting that they received the training and understand the procedures. The following rules will apply to drilling operations:

- Each rig must be equipped with emergency stop devices that will be tested daily to ensure that they are operational.
- Long handled shovels or equivalent shall be used to clear cuttings from the borehole and rotating equipment.
- The driller may not leave the controls when the augers are rotating.

6.2.2 Energized Systems (Contact with Underground or Overhead Utilities)

Underground utilities such as pressurized lines, water lines, telephone lines, buried utility lines, and high voltage power lines are known to be present throughout the facility. Clearance of underground and overhead utilities for each sample location will be coordinated with NWS Earle personnel. All work must be consistent with the SOP for Utility Locating and Excavation Clearance (See Attachment II of this HASP). Additionally, drilling operations will be conducted at a safe distance (>20 feet) from overhead power lines. Whenever underground utilities are suspected to be close to subsurface sampling locations, the borehole will be advanced to a minimum of 5 feet with a hand auger before drilling. As built drawings may also be used for additional clarification. In certain cases, NWS Earle personnel may need to de-energize electrical cables using facility lockout/tagout procedures to ensure electrical hazards are eliminated.

New Jersey One Call

In New Jersey the law requires you to call New Jersey One-Call at least three but no more than 10 business days before you dig (even with a shovel). New Jersey One-Call is a free utility locating service for homeowners and contractors throughout New Jersey. Within three business days of your call, the location of underground utilities will be marked. Call 1-800-272-1000 before you dig.

6.2.3 Ambient Temperature Extremes

Overexposure to high or low ambient temperatures (heat or cold stress) may exist during performance of this work depending on the project schedule. Work performed when ambient temperatures exceed 70°F may result in varying levels of heat stress (heat rash, heat cramps, heat exhaustion, and/or heat stroke) depending on variables such as wind speed, humidity, and percent sunshine, as well as physiological factors such as metabolic rate and skin moisture content. Additionally, work load and level of protective equipment will affect the degree of exposure. Site personnel will be encouraged to drink plenty of fluids to replace those lost through perspiration. Work performed when ambient temperatures are below 40°F may result in varying levels of cold stress (tremors, frostbite, wind burn, etc.) depending on variables such as wind speed, humidity, and percent sunshine, as well as physiological factors such as metabolic rate and skin moisture content. Additional information such as Work-Rest Regimens and personnel monitoring may be found in Section 4.0 of the Health and Safety Guidance Manual. The SSO will recommend additional heat or cold stress control measures as they are deemed necessary per American Conference of Governmental Industrial Hygienists (ACGIH) guidelines.

6.3 NATURAL HAZARDS

6.3.1 Insect/Animal Bites and Stings, Poisonous Plants, etc.

Contact with poisonous plants and bites or stings from poisonous insects are other natural hazards that must be considered. All site personnel who are allergic to stinging insects such as bees, wasps, and hornets must be particularly careful because severe illness and death may result from allergic reactions. As with a medical condition or allergy, information regarding the condition must be listed on the Medical Data Sheet and the FOL and SSO must be notified.

Ticks

During warm months (spring through early fall), tick-borne Lyme Disease may pose a potential health hazard. The longer a disease-carrying tick remains attached to the body, the greater the potential for contracting the disease. Wearing long sleeved shirts and long pants (tucked into boots) as well as performing frequent body checks will prevent long-term attachment. Site first aid kits should be equipped with medical forceps and rubbing alcohol to assist in tick removal. If necessary, tyvek coveralls can be worn to provide a barrier between the skin and ticks that may come into contact with clothing. Commercially available insect repellents have been shown to be effective at repelling ticks and other biting insects. For information regarding tick removal procedures and symptoms of exposure consult Attachment VII of this HASP or Section 4.0 of the Health and Safety Guidance Manual.

West Nile Virus

West Nile Virus (WNV) can spread to people and animals through the bite of an infected mosquito. Mosquitoes acquire the virus from infected birds. **Infected mosquitoes then transmit the West Nile virus to humans and animals when biting (or taking a blood-meal). West Nile encephalitis is NOT transmitted from person-to-person. There is no evidence that a person can get the virus from handling live or dead infected birds. However, avoid bare-handed contact when handling any dead animals, including dead birds. Ticks have not been implicated as vectors of West Nile-like virus.**

Prior to the detection of the virus in New York City, the virus, which can cause the brain infection encephalitis, WNV was found only in Africa, Eastern Europe and West Asia. **Mild infections are common and include fever, headache, and body aches, often with skin rash and swollen lymph glands. More severe infection is marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, occasional convulsions, paralysis and, rarely, death (especially in the elderly and very young). The incubation period of West Nile encephalitis is usually 3 to 12 days. There is no specific therapy or vaccine against West Nile encephalitis.** The vast majority of people who are bitten by an infected mosquito will develop only mild symptoms, if any.

In New Jersey, the legislation that established mosquito control, did so at the level of county government. All 21 counties have a mosquito control program of some kind. This network of county agencies interact with state government via the Departments of Health and Senior Services, Agriculture, Environmental Protection and the Agricultural Experiment Station at Rutgers University. New Jersey has a comprehensive plan for dealing with a possible return of the West Nile Virus. It includes enhanced mosquito control efforts; increased human, animal and mosquito surveillance; a streamlined system for testing collected samples, and a public education program.

Additional information can be obtained from the Monmouth County Mosquito Extermination Commission at (723) 542-3630.

Precautions

- **Limit outdoor activities during peak mosquito times – at dusk and dawn.**
- **Avoid standing water**
- **Wear long-sleeved shirts and long pants whenever you are outdoors.**
- **Apply insect repellent to exposed skin according to manufacturer instruction. An effective repellent will contain 20% to 30% DEET (N,N-diethyl-meta-toluamide). Avoid products containing more than 30% DEET.**
- **Spray clothing with repellents containing permethrin or DEET, mosquitoes may bite through thin clothing.**

6.3.2 Inclement Weather

Many of the project tasks will be performed outdoors. As a result, inclement weather may be encountered. If adverse weather (e.g., electrical storms, hurricanes, etc.) conditions arise, the FOL and/or SSO will temporarily suspend or terminate activities until hazardous conditions cease.

Tropical Storms and Hurricanes

As the NWS Earle, New Jersey area is in a tropical storm, hurricane prone area. The decision to curtail operations and evacuate the area should be made by the FOL, PM, and the HSM.

During the early summer to late fall months, typically from the first of June through the end of November, disturbances migrating off the West Coast of Africa move into the Atlantic Ocean and develop into tropical cyclones known as tropical storms and hurricanes. Many of these cyclones become strong enough to threaten life and property along the Eastern Seaboard and Gulf Coast. There are three main threats associated with tropical storms and hurricanes:

- High winds
- Excessive rainfall

- Storm surge

The impacts of high winds and excessive rainfall occur hours, maybe days, before the tropical storm or hurricane makes landfall. However, the storm surge accompanies the storm or hurricane at the time that landfall occurs.

7.0 AIR MONITORING

Direct reading instruments will be used at the site to detect and evaluate the presence of site contaminants and other potentially hazardous conditions. As a result, specific air monitoring measures and requirements are established in Table 5-1 pertaining to the hazards and tasks of an identified operation. Additionally Section 1.0, the Health and Safety Guidance Manual contains detailed information regarding direct reading instrumentation, as well as general calibration procedures of various instruments.

7.1 INSTRUMENTS AND USE

Instruments will be used primarily to monitor source points and worker breathing zone areas while observing instrument action levels. Action levels are discussed in Table 5-1 as they may apply to a specific task or location.

7.1.1 Flame Ionization Detector (FID) or Photoionization Detector (PID)

VOC contaminants of concern were previously detected at concentrations that are unlikely to present an inhalation exposure hazard to site workers. However, as a precautionary measure, an FID or a PID will be used to monitor for VOCs that may be present at source areas (such as soil boring locations) and within worker breathing zones during site activities. **If a PID is selected for use, it must be equipped with a lamp strength of at least 11.3 eV.** This requirement recognizes that the two substances previously identified in the groundwater at Site 13 (chloroform and methylene chloride) both have ionization potentials at this level. The use of a PID with a lamp energy of less than 11.3 eV would not detect these substances in the unlikely event that they are present in the air.

Before starting field activities, the background levels of the site must be determined and noted. Daily background readings will be taken away from areas of potential contamination. These readings, influencing conditions (weather, temperature, humidity, etc.), and site location must be documented in the field operations logbook or other site documentation (e.g., sample log sheet).

7.1.2 Hazard Monitoring Frequency

Table 5-1 presents the frequencies in which hazard monitoring will be performed as well as the action levels that will initiate the use of elevated levels of protection. The SSO may decide to increase these frequencies based on instrument responses and site observations. The frequency in which monitoring is performed will not be reduced without the prior consent of the PHSO or HSM.

7.2 INSTRUMENT MAINTENANCE AND CALIBRATION

Hazard monitoring instruments will be maintained and pre-field calibrated by the equipment provider (i.e., equipment rental company). Operational checks and field calibration must be performed on instruments each day before use. Field calibration will be performed on instruments according to manufacturer's recommendations (for example, the PID must be field calibrated daily and an additional field calibration must be performed at the end of each day to determine significant instrument drift). These operational checks and calibration efforts will be performed in a manner that complies with the manufacturer's recommendations and specifications. All calibration efforts must be documented. Figure 7-1 is provided for documenting these calibration efforts. This information may instead be recorded in a field operations logbook, provided that the information specified in Figure 7-1 is recorded. This required information includes the following:

- Date calibration was performed
- Individual calibrating the instrument
- Instrument name, model, and serial number
- Relevant instrument settings and resultant readings (before and after) calibration
- Identification of the calibration standard (lot no., source concentration, supplier)
- Relevant comments or remarks

Figure 7-1
Documentation of Field Calibration

SITE NAME: ______________________________ PROJECT NO.:____________

Date of Calibration	Instrument Name and Model	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot Number)	Remarks/ Comments
				Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration		

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section is included to specify health and safety training and medical surveillance requirements for both TtNUS and subcontractor personnel participating in site activities.

8.1.1 Requirements for TtNUS Personnel

All TtNUS personnel must complete 40 hours of introductory hazardous waste site training before working at Site 13 at NWS Earle. Additionally, TtNUS personnel who have had introductory training more than 12 months before site work must have completed 8 hours of refresher training within the past 12 months before being cleared for site work. In addition, 8-hour supervisory training in accordance with 29 CFR 1910.120(e)(4) will be required for site supervisory personnel.

Documentation of TtNUS introductory, supervisory, and refresher training as well as site-specific training will be maintained onsite. Copies of certificates or other official documentation will be used to fulfill this requirement.

TtNUS will conduct a pre-activities training session before initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short meeting will be held to discuss the operations completed and problems encountered. This activity will be supported through the use of Safe Work Permits (See Section 10.10).

8.1.2 Requirements for Subcontractors

All TtNUS subcontractor personnel must have completed introductory hazardous waste site training or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e) and 8 hours of refresher training meeting the requirements of 29 CFR 1910.120(e)(8) before performing field work at NWS Earle. TtNUS subcontractors must certify that each employee has had such training by sending TtNUS a letter on company letterhead containing the information in the example letter provided in Figure 8-1 and by providing copies of certificates for subcontractor personnel participating in site activities.

FIGURE 8-1.

TRAINING LETTER

The following statements must be typed on company letterhead, signed by an officer of the company, and accompanied by copies of personnel training certificates:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Daniel Witt, P.E.
Project Manager
Tetra Tech NUS, Inc.
661 Andersen Drive
Pittsburgh, PA 15220

Subject: HAZWOPER Training for NWS Earle, New Jersey

Dear Mr. Witt,

As an officer of XYZ Corporation, I hereby state that I am aware of the potential hazardous nature of the subject project. I also understand that it is our responsibility to comply with applicable occupational safety and health regulations, including those stipulated in Title 29 of the Code of Federal Regulations (CFR), Parts 1900 through 1910 and Part 1926.

I also understand that Title 29 CFR 1910.120, titled "Hazardous Waste Operations and Emergency Response," requires an appropriate level of training for certain employees engaged in hazardous waste operations. In this regard, I hereby state that the following employees have had 40 hours of introductory hazardous waste site training or equivalent work experience as requested by 29 CFR 1910.120(e) and have had 8 hours of refresher training as applicable and as required by 29 CFR 1910.120(e)(8) and that site supervisory personnel have had training in accordance with 29 CFR 1910.120(e)(4).

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

Should you have questions, please contact me at (555) 555-5555.

Sincerely,

(Name and Title of Company Officer)

8.2 SITE-SPECIFIC TRAINING

TtNUS will provide site-specific training to site personnel who will perform work on this project. Site-specific training will also be provided to other personnel [U.S. Department of Defense (DoD), Environmental Protection Agency (EPA), etc.] who may enter the site to perform functions that may or may not be directly related to site operations. Site-specific training will include:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present onsite
- Use of PPE
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the HASP
- Emergency response procedures (evacuation and assembly points)
- Spill response procedures
- Review of the contents of relevant MSDSs
- Review of Safe Work Permits

Site-specific documentation will be established through the use of Figure 8-2. All site personnel and visitors must sign this document upon receiving site-specific training.

8.3 MEDICAL SURVEILLANCE

8.3.1 Medical Surveillance Requirements for TtNUS Personnel

All TtNUS personnel participating in project field activities will have had a physical examination meeting the requirements of the TtNUS medical surveillance program and will be medically qualified to perform hazardous waste site work using respiratory protection.

Documentation for medical clearances will be maintained in the TtNUS Pittsburgh office and made available, as necessary.

FIGURE 8-2

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing site investigation activities at NWS Earle, New Jersey, and that I have received site-specific training that included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present onsite
- Use of PPE
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the HASP
- Emergency response procedures (evacuation and assembly points)
- Spill response procedures
- Review of contents of relevant MSDSs
- Review of the use of Safe Work Permits

I further state that I have been given the opportunity to ask questions, that my questions have been answered to my satisfaction, and that I agree to abide by the procedures and policies addressed in this plan. The date of my training (introductory, refresher, and supervisory, as applicable) and my medical surveillance requirements are accurate and correct to the best of my knowledge.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

8.3.2 Medical Surveillance Requirements for Subcontractors

Subcontractors are required to obtain a certificate of their ability to perform hazardous waste site work and to wear respiratory protection. The "Subcontractor Medical Approval Form" provided in Figure 8-3 shall be used to satisfy this requirement, providing it is properly completed and signed by a licensed physician.

Subcontractors who have a company medical surveillance program meeting the requirements of paragraph (f) of OSHA 29 CFR 1910.120 can substitute "Subcontractor Medical Approval Form" with a letter on company letterhead containing the information in the example letter presented in Figure 8-4 of this HASP.

8.3.3 Requirements for All Field Personnel

Each field team member (including subcontractors) and visitors entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet presented in Section 7 of the Health and Safety Guidance Manual. This shall be provided to the SSO, before participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTIONS

Subcontractors who will not enter the exclusion zone during operation and whose activities involve no potential for exposure to site contaminants will not be required to meet the requirements for training/medical surveillance other than site-specific training as stipulated in Section 8.2.

FIGURE 8-3

SUBCONTRACTOR MEDICAL APPROVAL FORM

For employees of ____
Company Name

Participant Name: ____________________________ Date of Exam: ___________________

Part A

The above-named individual has:

1. Undergone a physical examination in accordance with OSHA Standard 29 CFR 1910.120, paragraph (f), and was found to be medically -

   ( ) qualified to perform work at the NWS Earle work site
   ( ) not qualified to perform work at the NWS Earle work site

and,

2. Undergone a physical examination in accordance with OSHA 29 CFR 1910.134(b)(10) and was found to be medically -

   ( ) qualified to wear respiratory protection
   ( ) not qualified to wear respiratory protection

My evaluation has been based on the following information, as provided to me by the employer.

( ) A copy of OSHA Standard 29 CFR 1910.120 and appendices.
( ) A description of the employee's duties as they relate to the employee's exposures.
( ) A list of known/suspected contaminants and their concentrations (if known).
( ) A description of any PPE used or to be used.
( ) Information from previous medical examinations of the employee that is not readily available to the examining physician.

Part B

I, ____________________________, have examined ________________________________
Physician's Name (print) Participant's Name (print)

and have determined the following information:

FIGURE 8-3.

SUBCONTRACTOR MEDICAL APPROVAL FORM (CONTINUED)

1. Results of the medical examination and tests (excluding findings or diagnoses unrelated to occupational exposure):

   ____
   ____
   ____

2. Any detected medical conditions that would place the employee at increased risk of material impairment of the employee's health:

   ____
   ____
   ____

3. Recommended limitations on the employee's assigned work:

   ____
   ____
   ____

I have informed this participant of the results of this medical examination and any medical conditions that require further examination of treatment.

Based on the information provided to me, and in view of the activities and hazard potentials involved at the NWS Earle work site, this participant

( ) may
( ) may not

perform his/her assigned task.

Physician's Signature ______________________

Address ______________________

Phone Number ______________________

NOTE: Copies of test results are maintained and available at:

____
Address

FIGURE 8-4

MEDICAL SURVEILLANCE LETTER

The following statements must be typed on company letterhead and signed by an officer of the company:

LOGO
XYZ CORPORATION
555 E. 5th Street
Nowheresville, Kansas 55555

Month, day, year

Mr. Daniel Witt, P.E.
Project Manager
Tetra Tech NUS, Inc.
661 Andersen Drive
Pittsburgh, PA 15220

Subject: Medical Surveillance for NWS Earle, New Jersey

Dear Mr. Witt:

As an officer of XYZ Corporation, I hereby state that the persons listed below participated in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120, titled "Hazardous Waste Operations and Emergency Response: Final Rule." I further state that the persons listed below have had physical examinations under this program within the past 12 months and that they have been cleared by a licensed physician to perform hazardous waste site work and to wear positive- and negative-pressure respiratory protection. I also state that, to my knowledge, no person listed below has any medical restriction that would preclude him/her from working at the NWS Earle, New Jersey site.

LIST FULL NAMES OF EMPLOYEES AND THEIR SOCIAL SECURITY NUMBERS HERE.

Should you have questions, please contact me at (555) 555-5555.

Sincerely,

(Name and Title of Company Officer)

9.0 SPILL CONTAINMENT PROGRAM

9.1 SCOPE AND APPLICATION

It is not anticipated that quantities of bulk potentially hazardous materials (greater than 55 gallons) will be handled during site activities conducted as part of the scope of work. Small quantities of waste water (decontamination) and Investigative-Derived Waste (IDW) may be generated as part of site activities. It is not anticipated, however, that spillage of these materials would constitute a significant danger to human health or the environment. Furthermore, it is possible that as the job progresses disposable PPE and other nonreusable items may be generated. As needed, 55-gallon drums will be used to contain waste water, IDW, and other unwanted items generated during investigation activities. These drums will be labeled with the site name and address, the type of contents, and the date the container was filled as well as contact person. Samples will be collected and analyzed to characterize the material and determine appropriate disposal measures. Once characterized they can be removed from the staging area and disposed of in accordance with Federal, state, and local regulations.

9.2 POTENTIAL SPILL AREAS

Potential spill areas will be monitored in an ongoing attempt to prevent and control further potential contamination of the environment. Currently, various areas are vulnerable to this hazard including the areas used for central staging and decontamination activities. Additionally, areas designated for handling, loading, and unloading of potentially contaminated soils, waters, and debris present limited potential for leaks or spills. It is anticipated that IDW generated as a result of this scope of work will be containerized, labeled, and staged to await chemical analyses. The results of these analyses will determine appropriate disposal methods.

9.3 LEAK AND SPILL DETECTION

To establish an early detection of potential spills or leaks, periodic inspections by the SSO will be conducted during working hours to visually determine that containers are not leaking. If a leak is detected, the first approach will be to transfer the container contents using a hand pump into a new container. Other provisions for the transfer of container contents will be made and appropriate emergency contacts will be notified, if necessary. In most instances, leaks will be collected and contained using absorbents such as Oil-dry, vermiculite, or sand, which will be stored at the staging area in a conspicuously marked drum. This material, too, will be containerized for disposal pending analyses. All inspections will be documented in the Project Logbook.

9.4 PERSONNEL TRAINING AND SPILL PREVENTION

All personnel will be instructed on the procedures for spill prevention, containment, and collection of hazardous materials in the site-specific training. The FOL and/or the SSO will serve as the Spill Response Coordinator for this operation if necessary.

9.5 SPILL PREVENTION AND CONTAINMENT EQUIPMENT

The following represents the types of equipment that may be maintained at the staging area for the purpose of supporting this Spill Prevention/Containment Program.

- Sand, clean fill, vermiculite, or other noncombustible absorbent (oil-dry);
- Drums (55-gallon U.S. DOT 17-E or 17-H)
- Shovels, rakes, and brooms
- Labels

9.6 SPILL CONTROL PLAN

This section describes the procedures the TtNUS field crewmembers will use when detecting a spill or leak.

1) Notify the SSO or FOL immediately.

2) Use PPE stored at the staging area. Take immediate actions to stop the leak or spill by plugging or patching the drum or raising the leak to the highest point. Spread the absorbent material in the area of the spill covering completely.

3) Transfer the material to a new container, and collect and containerize the absorbent material. Label the new container appropriately. Await analyses for treatment or disposal options.

4) All spills will be recontainerized with 2 inches of top cover and await test results for treatment or disposal options.

It is not anticipated that a spill will occur that the field crews cannot handle. Should this occur, however, the FOL or SSO will notify the NWS Earle Emergency Coordinator who will notify the appropriate emergency response agencies.

10.0 SITE CONTROL

This section outlines the means by which TtNUS will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. It is anticipated that a three-zone approach will be used during work at this site. This three-zone approach will use an exclusion zone, a contamination reduction zone, and a support zone. It is also anticipated that this control measure will be used to control access to site work areas. Use of such controls will restrict the general public, minimize the potential for the spread of contaminants, and protect individuals who are not cleared to enter work areas.

10.1 EXCLUSION ZONE

The exclusion zone will be considered those areas of the site of known or suspected contamination. It is not anticipated that significant amounts of surface contamination are present in the proposed work areas of this site. It is anticipated that this will remain so until/unless contaminants are brought to the surface by intrusive activities, such as soil boring or sampling operations. Furthermore, once intrusive activities have been completed and surface contamination has been removed, the potential for exposure is again diminished and the area can then be reclassified as part of the contamination reduction zone. Therefore, the exclusion zones for this project will be limited to those areas of the site where active work is being performed plus a designated area surrounding the point of operation. When possible, exclusion zones will be delineated using barrier tape, cones and/or drive poles, and postings to inform site personnel.

The exclusion zone will be considered those areas of active operations plus an established safety zone depending on the task. The following represent the exclusion zone boundaries for the following identified tasks:

- Soil Boring – The boundary perimeter will be established by determining the height of the mast, plus five feet. Therefore, if it is a 35-foot mast plus 5 feet equals a 40-foot boundary surrounding the point of operation.

- Decontamination (heavy equipment – steam/pressure washers) – 35 feet surrounding the point of operation. This will take place at a centralized location.

10.1.1 Exclusion Zone Clearance

Before the initiation of site activities, utility locations will be identified following the guidance provided in the TtNUS SOP For Utility Locating and Excavation Clearance (see Attachment II). Additional utility surveys may be conducted by TtNUS through the use of available documentation provided by NWS Earle and/or local utility companies. The positions of identified utilities will be field located and staked to minimize the potential for damage during intrusive activities. Sample locations can be located to avoid buried utilities. In the event that a utility is struck during a subsurface investigative activity, the emergency numbers provided in Table 2-1 will be notified.

Access to work areas will be controlled by TtNUS personnel. No personnel will be permitted to enter site exclusion zones without site-specific training. Site visitors will be provided site-specific training and will be escorted by TtNUS personnel (see section 10.4).

10.2 CONTAMINATION REDUCTION ZONE

The contamination reduction zone (CRZ) is a buffer area between the exclusion zone and areas of the site where contamination is not suspected. The personnel and equipment decontamination will not take place in this area, but will take place at a central location established for this project. This area instead will serve as a focal point in supporting exclusion zone activities. When applicable, this area will be delineated using barrier tape, cones and/or drive poles, and postings to inform and direct facility personnel.

10.3 SUPPORT ZONE

The support zone for this project will include a staging area where site vehicles will be parked, equipment will be unloaded, and food and drink containers will be maintained. The support zones will be established at areas of the site where exposure to site contaminants would not be expected during normal working conditions or foreseeable emergencies.

10.4 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by TtNUS
- Regulatory personnel (NJDEP, EPA, OSHA, etc.)
- NWS Earle personnel

- Other authorized visitors

All personnel working on this project are required to gain initial access to the site by coordinating with the TtNUS FOL or designee and following established site access procedures.

Upon gaining access to the site, site visitors wishing to observe operations in progress will be escorted by a TtNUS representative (arranged for by the FOL) and shall be required to meet the minimum requirements discussed below:

- All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), the entity which they represent, and the purpose of the visit.

- All site visitors will be required to produce the necessary information supporting clearance to the site. This shall include information attesting to applicable training (40 hours of HAZWOPER training) and medical surveillance as stipulated in Section 8.0 of this document. In addition, to enter the site operational zones during planned activities, visitors will be required to first go through site-specific training covering the topics stipulated in Section 8.2 of this HASP.

Once the site visitors have completed the above items, they will be permitted to enter the operational zone. All visitors are required to observe the protective equipment and site restrictions in effect at the site at the time of their visit. Visitors not meeting the requirements stipulated in this plan will not be permitted to enter the site operational zones during planned activities. Incidences of unauthorized site visitation will cause the termination of onsite activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from the FOL, SSO, or on-site security personnel.

10.5 SITE SECURITY

Site security will be accomplished using existing NWS Earle security resources and procedures, supplemented by TtNUS or subcontractor personnel, if necessary. TtNUS will retain control over active operational areas. The first line of security will take place at the base boundaries restricting the general public. The second line of security will take place at the work site referring interested parties to the FOL. The FOL will serve as a focal point for site personnel and will serve as the final line of security and the primary enforcement contact.

10.6 SITE MAPS

Once the areas of contamination, access routes, utilities, topography, and dispersion routes are determined, a site map will be generated and adjusted as site conditions change. These maps will show utility locations, potential points of contact with the public, roadways, and other significant characteristics that may impact site operations and safety. Site maps will be posted to illustrate up-to-date collection of contaminants and adjustment of zones and access points.

10.7 BUDDY SYSTEM

Personnel engaged in onsite activities will practice the "buddy system" to ensure the safety during this operation.

10.8 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

TtNUS and subcontractor personnel will provide MSDSs for chemicals brought onsite. The contents of these documents will be reviewed by the SSO with the user(s) of the chemical substances before an actual use or application of the substances onsite. A chemical inventory of chemicals used onsite will be developed using Section 5.0 of the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location and will be available for anyone to review on request.

10.9 COMMUNICATION

As TtNUS personnel may not be working in close proximity to each other at NWS Earle a combination of communication methods will be used. Two-way radios, cellular and conventional telephone, hand signals, voice commands, and line of site will provide be utilized when most appropriate. When project tasks are performed simultaneously on different sites, vehicle horns will be used to communicate emergency situations as described in Section 2.6 of this HASP. All radio frequency transmitting devices, including cell phones and two way radios, must be approved by NWS Earle Radio Shop. All units cleared for Hazards of Electromagnetic Radiation to Ordnance (HERO) will be labeled as safe. Only these devices will be permitted in the OB/OD unit.

External communication will be accomplished by using provided telephones at the site. External communication will primarily be used for the purpose of resource and emergency resource communications.

10.10 SAFE WORK PERMITS

All exclusion zone work conducted in support of this project will be performed using Safe Work Permits to guide and direct field crews on a task-by-task basis. An example of the Safe Work Permit to be used is illustrated in Figure 10-1. The daily meetings conducted during their generation will further support these work permits. This effort will ensure site-specific considerations and changing conditions are incorporated into the planning effort.

Use of these permits will provide the communication line for reviewing protective measures and hazards associated with each operation. This HASP will be used as the primary reference for selecting levels of protection and control measures. The work permit will take precedence over the HASP when more conservative measures are required based on specific site conditions.

The FOL and/or the SSO will be responsible for completing the Safe Work Permit and issuing them to the appropriate parties. Site personnel at the end of each day will turn in the permit(s) used for that day to the SSO. All permits will be maintained as part of the permanent project files attesting to safety and health measures used for a given task at a given time and place. Problems encountered with the protective measures required should be documented on the permit and brought to the attention of the SSO.

FIGURE 10-1

SAFE WORK PERMIT

Permit No. ______________ Date: __________________ Time: From ____________ to _____________

SECTION A: General Job Scope (To be filled in by person performing work)

I. Work limited to the following (description, area, equipment used): ______________________________

II. Names: ______________________________

III. Onsite Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ ____________
TtNUS

SECTION B: Health and Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☐ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ (see reverse)
No ☐

Modifications/Exceptions: ______________________________

V.

Chemicals of Concern	Action Level(s)	Response Measures

VI. Additional Safety Equipment/Procedures

Hardhat................................ ☐ Yes ☐ No
Safety Glasses..................... ☐ Yes ☐ No
Chemical/splash goggles ..... ☐ Yes ☐ No
Splash Shield .... ☐ Yes ☐ No
Splash suits/coveralls........... ☐ Yes ☐ No
Steel toe/shank Workboots .. ☐ Yes ☐ No

Hearing Protection (Plugs/Muffs).... ☐ Yes ☐ No
Safety belt/harness .... ☐ Yes ☐ No
Radio .... ☐ Yes ☐ No
Barricades .... ☐ Yes ☐ No
Gloves (Type) .... ☐ Yes ☐ No
Work/rest regimen .... ☐ Yes ☐ No

Modifications/Exceptions: ______________________________

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)..........	☐	☐	Emergency alarms..................	☐	☐
Procedure for safe job completion......................	☐	☐	Evacuation routes....................	☐	☐
Contractor tools/equipment inspected................	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.)..................... ☐ Yes ☐ No
If yes, fill out appropriate section(s) on safety work permit addendum

X. Special instructions, precautions: ______________________________

Permit Issued by: ______________________________ Permit Accepted by: ______________________
Job Completed by: ______________________________ Date: ______________________

11.0 CONFINED SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces.** A confined space is defined as an area that has one or more of the following characteristics:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is one that:

- Contains or has a potential to contain a hazardous atmosphere (including excavations deeper than 4 feet).
- Contains a material that has the potential to engulf an entrant (including excavations).
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section.
- Contains other recognized serious safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The TtNUS FOL shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets
- MSDSs for chemicals brought onsite, including decon solutions, fuels, lime, sample preservatives, calibration gases, etc.
- A full-size OSHA Job Safety and Health Poster (posted in the site trailers)
- Training/Medical Surveillance Documentation Form (Blank)
- Emergency Reference Information (Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations in which posting these documents is not feasible (such as no office trailer), these documents should be separated and immediately accessible.

Chemical Inventory Listing (posted) - This list represents chemicals brought onsite, including decontamination solutions, sample preservations, fuel, etc. This list should be posted in a central area.

Material Safety Data Sheets (MSDSs) (maintained) - The MSDSs should also be in a central area accessible to site personnel. These documents should match the listings on the chemical inventory list for substances used onsite. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster (posted) - This poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaced, altered, or covered by other material.

Site Clearance (maintained) - This list is found within the training section of the HASP (See Figure 8-2). This list identifies site personnel, dates of training (including site-specific training), and medical surveillance. The lists indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) (posted) - This list of numbers and directions will be maintained at phone communications points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be completed by onsite personnel and filed in a central location. The Medical Data Sheet will accompany an injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to personnel to carry with them.

Hearing Conservation Standard (29 CFR 1910.95) (posted) - This standard will be posted when hearing protection or other noise abatement procedures are used.

Personnel Monitoring (maintained) - All results generated through personnel sampling (levels of airborne toxins, noise levels, etc.) will be posted to inform individuals of the results of that effort.

Placards and Labels (maintained) - Where chemical inventories have been separated because of quantities and incompatibilities, these areas will be conspicuously marked using Department of Transportation (DOT) placards and acceptable (Hazard Communication 29 CFR 1910.1200(f)) labels.

The purpose, as stated above, is to allow site personnel quick access to this information. Variations concerning location and methods of presentation are acceptable as long as the objection is accomplished.

13.0 GLOSSARY

ACGIH	American Conference of Governmental Industrial Hygienists
APR	Air Purifying Respirator
CFR	Code of Federal Regulations
CIH	Certified Industrial Hygienist
CNS	Central Nervous System
CRZ	Contamination Reduction Zone
CSP	Certified Safety Professional
dBA	Decibel on the A weighting scale
DoD	Department of Defense
DOT	Department of Transportation
EPA	Environmental Protection Agency
eV	electron Volts
FID	Flame Ionization Detector
FOL	Field Operations Leader
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSM	Health and Safety Manager
IDW	Investigative Derived Waste
IP	Ionization Potential
LEL	Lower Explosive Limit
LFL	Lower Flammable Limit
mg/m^3	Milligrams per cubic meter
mmHg	millimeters mercury
MSDS	Material Safety Data Sheet
NIOSH	National Institute of Occupational Safety and Health
NJDEP	New Jersey Department of Environmental Protection
NWS	Naval Weapons Station
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PCB	Polychlorinated Biphenyls
PHSO	Project Health and Safety Officer
PID	Photoionization Detector
PPE	Personal Protective Equipment
PPM	Parts per Million
SOP	Standard Operating Procedure
SSO	Site Safety Officer

ATTACHMENT I

INJURY/ILLNESS PROCEDURE AND REPORT FORM

TETRA TECH NUS, INC.

INJURY/ILLNESS PROCEDURE
WORKER'S COMPENSATION PROGRAM

WHAT YOU SHOULD DO IF YOU ARE INJURED OR DEVELOP AN ILLNESS AS A RESULT OF YOUR EMPLOYMENT:

- Stop work as needed to ensure no further harm is done.
- If injury is minor, obtain appropriate first aid treatment.
- If injury or illness is severe or life threatening, obtain professional medical treatment at the nearest hospital emergency room. Check with your office location or project health and safety plan for specific instructions.
- If incident involves an injury, illness, or chemical exposure on a project work site, follow instructions in the Health & Safety Plan.
- Immediately report any injury or illness to your supervisor or office manager. In addition, you must contact your Human Resources representative, Marilyn Duffy at (412) 921-8475, and the Corporate Health and Safety Manager, Matt Soltis at (412) 921-8912 within 24 hours of the injury. You will be required to complete an Injury/Illness Report. You may also be required to participate in a more detailed investigation with the Health Sciences Department.
- In the event of a serious near-miss incident, a "Serious Near Miss Report" (Form AR-2, available online at https://go2.tetratech.com under "Departments", "Health and Safety", "Accident Reporting Procedures", hyperlink for "Serious Near Miss Report") must be completed and faxed to the Corporate Health and Safety Manager within 48 hours.
- If further medical treatment is needed, our insurance carrier, ACE, will provide information on the authorized providers customized to the location of the injured employee. You can find this information by accessing the website of ACE's claims handler, ESIS, at: **www.esis.com.** These providers are to be used for treatment of Worker's Compensation injuries subject to the laws of the state in which you work.

ADDITIONAL QUESTIONS REGARDING WORKER'S COMPENSATION:

Contact your local Human Resources representative (Marilyn Duffy), Corporate Health and Safety Manager (Matt Soltis), or Corporate Administration in Pasadena, California, at (626) 351-4664.

Worker's compensation is a state-mandated program that provides medical and disability benefits to employees who become disabled due to job related injury or illness. Tetra Tech, Inc. and its subsidiaries pay premiums on behalf of their employees. This program is based on a no-fault system, and benefits are provided for covered events as an exclusive remedy to the injured employee regardless of fault. The types of injuries or illnesses covered and the amount of benefits paid are regulated by the state worker's compensation boards and vary from state to state. Corporate Administration in Pasadena is responsible for administering the Company's worker's compensation program. The following is a general explanation of worker's compensation provided in the event that you become injured or develop an illness as a result of your employment with Tetra Tech or any of its subsidiaries. Please be aware that the term used for worker's compensation varies from state to state.

WHO IS COVERED:

All employees of Tetra Tech, whether they are on a full-time, part-time or temporary status, working in an office or in the field, are entitled to worker's compensation benefits from the first day of work. All employees must follow the above injury/illness reporting procedures. If you are working out-of-state and away from your home office, you are still eligible for worker's compensation benefits.

Consultants, independent contractors, and employees of subcontractors and employees from temporary employment agencies are not covered by Tetra Tech's Worker's Compensation plan.

WHAT IS COVERED:

If you are injured or develop an illness caused by your employment, worker's compensation benefits are available to you subject to the laws of the state you work in. Injuries do not have to be serious; even injuries treated by first aid practices are covered and must be reported.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT

To: ______________________________
Subsidiary Health and Safety Representative

cc: ______________________________
Workers Compensation Administrator

Project name: ______________________

Project number: ____________________

Prepared by: ______________________

Position: __________________________

Office: ____________________________

Telephone number: __________________

Fax number: ________________________

Information Regarding Injured or Ill Employee

Name: ______________________________

Home address: ______________________

____

Home telephone number: _____________

Occupation (regular job title): _____

Department: ________________________

Office: ____________________________

Gender: M ☐ F ☐ No. of dependents: _______

Marital status: ____________________

Date of birth: _____________________

Social security number: ____________

Date of Accident: ______________

Time Employee Began Work: ______

Time of Accident: __________ a.m. ☐ p.m. ☐

☐ Check if time cannot be determined

Location of Incident

Street address: ____________________

City, state, and zip code: __________

County: ____________________________

Was place of accident or exposure on employer's premises? Yes ☐ No ☐

Information About the Incident

What was the employee doing just before the incident occurred? Describe the activity as well as the tools, equipment, or material the employee was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from hand sprayer"; "Daily computer key-entry"

What Happened? Describe how the injury occurred. Examples: "When ladder slipped on wet floor, worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; "Worker developed soreness in wrist over time"

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT (Continued)

Information About the Incident (Continued)

What was the injury or illness? Describe the part(s) of the body affected and how it was affected. Be more specific than "hurt," "pain," or "sore." Examples "Strained back"; "Chemical burn, right hand"; "Carpal tunnel syndrome, left wrist"

Describe the Object or Substance that Directly Harmed the Employee: Examples: "Concrete floor"; "Chlorine"; "Radial arm saw." If this question does not apply to the incident, write "Not applicable."

Did the employee die? Yes ☐ No ☐ Date of death: ____________________

Was employee performing regular job duties? Yes ☐ No ☐

Was safety equipment provided? Yes ☐ No ☐ Was safety equipment used? Yes ☐ No ☐

Note: Attach any police reports or related diagrams to this report.

Witness (Attach additional sheets for other witnesses.)

Name: ____________________

Company: ____________________

Street address: ____________________

City: ____________________ State: __________ Zip code: __________

Telephone number: ____________________

Medical Treatment Required? ☐ Yes ☐ No ☐ First aid only

Name of physician or health care professional: ____________________

If treatment was provided away from the work site, provide the information below.

Facility name: ____________________

Street address: ____________________

City: ____________________ State: __________ Zip code: __________

Telephone number: ____________________

Was the employee treated in an emergency room? ☐ Yes ☐ No

Was the employee hospitalized over night as an in-patient? ☐ Yes ☐ No

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT (Continued)

Corrective Action(s) Taken by Unit Reporting the Accident:

Corrective Action Still to be Taken (by whom and when):

Name of Tetra Tech employee the injury or illness was first reported to: ______________________

Date of Report: ______________________ **Time of Report:** ______________________

I have reviewed this investigation report and agree, to the best of my recollection, with its contents.

______________________ ______________________

Printed Name of Injured Employee Telephone Number

______________________ ______________________

Signature of Injured Employee Date

The signatures provided below indicate that appropriate personnel have been notified of the incident.

Title	Printed Name	Signature	Telephone Number	Date
Office Manager				
Project Manager				
Site Safety Coordinator or Office Health and Safety Representative				

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

TETRA TECH, INC.

ACCIDENT AND ILLNESS INVESTIGATION REPORT (Continued)

To Be Completed by the Subsidiary Health and Safety Representative

Classification of Incident:

☐ Injury ☐ Illness

Result of Incident:

☐ First aid only

☐ Days away from work

☐ Remained at work but incident resulted in job transfer or work restriction

☐ Incident involved days away and job transfer or work restriction

☐ Medical treatment only

No. of days away from work ______________________

Date employee left work ______________________

Date employee returned to work ______________________

No. of days placed on restriction or job transfer: ______________________

OSHA Recordable Case Number ______________________

To Be Completed by Human Resources

Social security number: ______________________

Date of hire: ______________ Hire date for current job: ______________

Wage information: $ __________ per ☐ Hour ☐ Day ☐ Week ☐ Month

Position at time of hire: ______________________

Current position: ______________ Shift hours: ______________

State in which employee was hired: ______________________

Status: ☐ Full-time ☐ Part-time Hours per week: ________ Days per week: ________

Temporary job end date: ______________________

To Be Completed during Report to Workers Compensation Carrier

Date reported: ______________ Reported by: ______________

Confirmation number: ______________________

Name of contact: ______________________

Field office of claims adjuster: ______________________

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

ATTACHMENT II

STANDARD OPERATING PROCEDURE
FOR
UTILITY LOCATING
AND
EXCAVATION CLEARANCE

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number HS-1.0	Page 1 of 15
		Effective Date 12/03	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Health & Safety	
Subject UTILITY LOCATING AND EXCAVATION CLEARANCE		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
OSHA 29 CFR 1926(b)(2)
OSHA 29 CFR 1926(b)(3)
TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

ONE-CALL SYSTEMS INTERNATIONAL CONDENSED DIRECTORY

Alabama
Alabama One-Call
1-800-292-8525

Alaska
Locate Call Center of Alaska, Inc.
1-800-478-3121

Arizona
Arizona Blue Stake
1-800-782-5348

Arkansas
Arkansas One Call System, Inc.
1-800-482-8998

California
Underground Service Alert North
1-800-227-2600
Underground Service Alert of Southern California
1-800-227-2600

Colorado
Utility Notification Center of Colorado
1-800-922-1987

Connecticut
Call Before You Dig
1-800-922-4455

Delaware
Miss Utility of Delmarva
1-800-282-8555

Florida
Sunshine State One-Call of Florida, Inc.
1-800-432-4770

Georgia
Underground Protection Center, Inc.
1-800-282-7411

Hawaii
Underground Service Alert North
1-800-227-2600

Idaho
Dig Line Inc.
1-800-342-1585
Kootenai County One-Call
1-800-428-4950
Shoshone - Benewah One-Call
1-800-398-3285

Illinois
JULIE, Inc.
1-800-892-0123
Digger (Chicago Utility Alert Network)
312-744-7000

Indiana
Indiana Underground Plant Protection Service
1-800-382-5544

Iowa
Iowa One-Call
1-800-292-8989

Kansas
Kansas One-Call System, Inc.
1-800-344-7233

Kentucky
Kentucky Underground Protection Inc.
1-800-752-6007

Louisiana
Louisiana One Call System, Inc.
1-800-272-3020

Maine
Dig Safe System, Inc.
1-888-344-7233

Maryland
Miss Utility
1-800-257-7777
Miss Utility of Delmarva
1-800-282-8555

Massachusetts
Dig Safe System, Inc.
1-888-344-7233

Michigan
Miss Dig System, Inc.
1-800-482-7171

Minnesota
Gopher State One Call
1-800-252-1166

Mississippi
Mississippi One-Call System, Inc
1-800-227-6477

Missouri
Missouri One-Call System, Inc.
1-800-344-7483

Montana
Utilities Underground Protection Center
1-800-424-5555
Montana One Call Center
1-800-551-8344

Nebraska
Diggers Hotline of Nebraska
1-800-331-5666

Nevada
Underground Service Alert North
1-800-227-2600

New Hampshire
Dig Safe System, Inc.
1-888-344-7233

New Jersey
New Jersey One Call
1-800-272-1000

New Mexico
New Mexico One Call System, Inc.
1-800-321-2537
Las Cruces- Dona Ana Blue Stakes
1-888-526-0400

New York
Dig Safely New York
1-800-962-7962
New York City- Long Island One Call Center
1-800-272-4480

North Carolina
The North Carolina One-Call Center, Inc.
1-800-632-4949

North Dakota
North Dakota One-Call
1-800-795-0555

Ohio
Ohio Utilities Protection Service
1-800-362-2764
Oil & Gas Producers Underground Protect'n Svc
1-800-925-0988

Oklahoma
Call Okie
1-800-522-6543

Oregon
Oregon Utility Notification Center/One Call Concepts
1-800-332-2344

Pennsylvania
Pennsylvania One Call System, Inc.
1-800-242-1776

Rhode Island
Dig Safe System, Inc.
1-888-344-7233

South Carolina
Palmetto Utility Protection Service Inc.
1-888-721-7877

South Dakota
South Dakota One Call
1-800-781-7474

Tennessee
Tennessee One-Call System, Inc.
1-800-351-1111

ATTACHMENT 1 (Continued)

Texas
Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah
Blue Stakes of Utah
1-800-662-4111

Vermont
Dig Safe System, Inc.
1-888-344-7233

Virginia
Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington
Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating Council
509-456-8000

West Virginia
Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin
Diggers Hotline, Inc.
1-800-242-8511

Wyoming
Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia
Miss Utility
1-800-257-7777

Alberta
Alberta One-Call Corporation
1-800-242-3447

British Columbia
BC One Call
1-800-474-6886

Ontario
Ontario One-Call System
1-800-400-2255

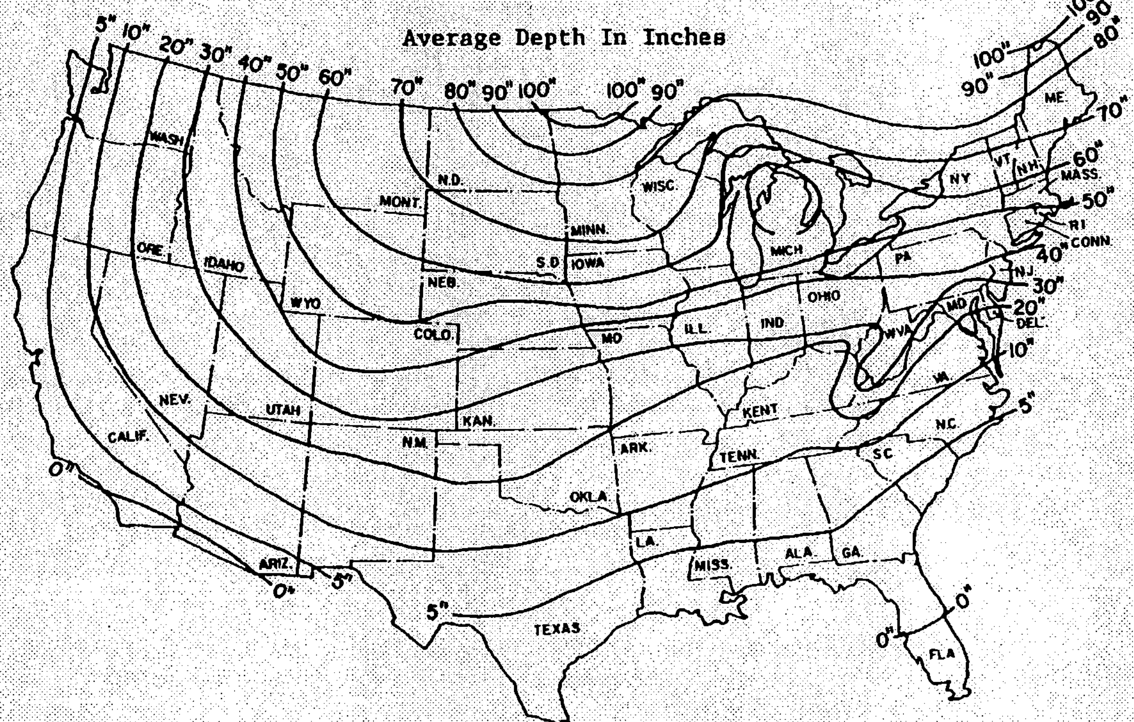
Quebec
Info-Excavation
1-800-663-9228

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION

FROST PENETRATION

Average Depth In Inches



Courtesy U.S. Department Of Commerce

ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: ____________________ Project Name: ________________________________

Project No.: ______________________ Completed By: ______________________________

Location Name: _________________________ Work Date: ____________________________

Excavation Method/Overhead Equipment: ____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes no N/A
b)	Interview local personnel?	yes no N/A
c)	Site visit and inspection?	yes no N/A
d)	Excavation areas marked in the field?	yes no N/A
e)	Utilities located in the field?	yes no N/A
f)	Located utilities marked/added to site maps?	yes no N/A
g)	Client contact notified Name _____________ Telephone: _________ Date: _____________	yes no N/A
g)	State One-Call agency called? Caller: ________________________________ Ticket Number: _________________________ Date: _____________	yes no N/A
h)	Geophysical survey performed? Survey performed by: ____________________ Method: ______________________________ Date: _____________	yes no N/A
i)	Hand excavation performed (with concurrent use of utility detection device)? Completed by: __________________________ Total depth: __________ feet Date: _______	yes no N/A
j)	Trench/excavation probed? Probing completed by: ____________________ Depth/frequency: ________________________ Date: _____________	yes no N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes no N/A
b)	Marked on site maps	yes no N/A
c)	Necessary to lockout/insulate/re-route	yes no N/A
d)	Document procedures used to lockout/insulate/re-route	yes no N/A
e)	Minimum acceptable clearance (SOP Section 5.2): _________________	

3. Notes:

____

____

____

Approval:

______________________________ ______________________

Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

ATTACHMENT 4
OSHA LETTER OF INTERPRETATION

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

Question: *Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.*

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651(Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

> When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

ATTACHMENT 4 (Continued)

> When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by <u>safe and acceptable means</u>. (emphasis added).

Therefore, "acceptable means" must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either "other acceptable means" or "safe and acceptable means." The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified "careful probing or hand digging" as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language "to allow other, *equally effective means* of locating such installations." The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used <u>*where the utilities have not been marked and detection equipment is not being used*</u> – "probing with hand-held tools." This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

> OSHA received two comments * * * and input from ACCSH [OSHA's Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping 'such as probing with hand-held tools' from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of "acceptable means" in the final provision.

<u>Non-conductive hand tools are permitted</u>

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a "shooter" (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, <u>when used with appropriate caution</u>, is an "acceptable means" for locating underground utilities.

ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA=s interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at http://www.osha.gov.

ATTACHMENT III

EQUIPMENT INSPECTION CHECKLIST

EQUIPMENT INSPECTION

COMPANY:______________________________ **UNIT NO.**______________

FREQUENCY: Inspect daily, document prior to use and as repairs are needed.

Inspection Date: ____/____/____ Time: _______ Equipment Type:______________________ (e.g., bulldozer)

	Good	Need Repair	N/A
Tires or tracks	❒	❒	❒
Hoses and belts	❒	❒	❒
Cab, mirrors, safety glass	❒	❒	❒
- Turn signals, lights, brake lights, etc. (front/rear) for equipment approved for highway use?	❒	❒	❒
- Is the equipment equipped with audible back-up alarms and back-up lights?	❒	❒	❒
Horn and gauges	❒	❒	❒
Brake condition (dynamic, park, etc.)	❒	❒	❒
Fire extinguisher (Type/Rating -___________)	❒	❒	❒
Fluid Levels:			
- Engine oil	❒	❒	❒
- Transmission fluid	❒	❒	❒
- Brake fluid	❒	❒	❒
- Cooling system fluid	❒	❒	❒
- Windshield wipers	❒	❒	❒
- Hydraulic oil	❒	❒	❒
Oil leak/lube	❒	❒	❒
Coupling devices and connectors	❒	❒	❒
Exhaust system	❒	❒	❒
Blade/boom/ripper condition	❒	❒	❒
Accessways: Frame, hand holds, ladders, walkways (non-slip surfaces), guardrails?	❒	❒	❒
Power cable and/or hoist cable	❒	❒	❒
Steering (standard and emergency)	❒	❒	❒

Safety Guards:	**Yes**	**No**
– Around rotating apparatus (belts, pulleys, sprockets, spindles, drums, flywheels, chains) all points of operations protected from accidental contact?______________________	❒	❒
– Hot pipes and surfaces exposed to accidental contact?______________________	❒	❒
– All emergency shut offs have been identified and communicated to the field crew?__________	❒	❒
– Have emergency shutoffs been field tested? ______________________	❒	❒
– Results?______________________	❒	❒
- Are any structural members bent, rusted, or otherwise show signs of damage?__________	❒	❒
– Are fueling cans used with this equipment approved type safety cans?__________	❒	❒

- Have the attachments designed for use (as per manufacturer's recommendation) with this equipment been inspected and are considered suitable for use?______________ ❐ ❐

Portable Power Tools:

- Tools and Equipment in Safe Condition?______________ ❐ ❐
- Saw blades, grinding wheels free from recognizable defects (grinding wheels have been sounded)? ❐ ❐
- Portable electric tools properly grounded?______________ ❐ ❐
- Damage to electrical power cords?______________ ❐ ❐
- Blade guards in place?______________ ❐ ❐
- Components adjusted as per manufacturers recommendation?______________ ❐ ❐

Cleanliness:

- Overall condition (is the decontamination performed prior to arrival on-site considered acceptable)?______________
- Where was this equipment used prior to its arrival on site?______________
- Site Contaminants of concern at the previous site?______________
- Inside debris (coffee cups, soda cans, tools and equipment) blocking free access to foot controls?______________

Operator Qualifications (as applicable for all heavy equipment):

- Does the operator have proper licensing where applicable, (e.g., CDL)?______________
- Does the operator, understand the equipments operating instructions?______________
- Is the operator experienced with this equipment? ______________
- Does the operator have emotional and/or physical limitations which would prevent him/her from performing this task in a safe manner?______________
- Is the operator 21 years of age or more?______________

Identification:

- Is a tagging system available, for positive identification, for tools removed from service?___

Additional Inspection Required Prior to Use On-Site

	Yes	No
– Does equipment emit noise levels above 90 decibels?	❐	❐
– If so, has an 8-hour noise dosimetry test been performed?	❐	❐

- Results of noise dosimetry:______________
- Defects and repairs needed:______________
- General Safety Condition: ______________
- Operator or mechanic signature:______________

Approved for Use: ❐ Yes ❐ No

____
Site Safety Officer Signature

ATTACHMENT IV

SAFE WORK PERMITS

SAFE WORK PERMIT FOR MOBILIZATION AND DEMOBILIZATION ACTIVITIES AT NWS EARLE COLTS NECK, NEW JERSEY

Permit No. ______________ Date: __________________ Time: From ____________ to _____________

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Mobilization and demobilization activities.

II. Required Monitoring Instruments: None

III. Field Crew: ____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ TtNUS ____________

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ (see reverse)
No ☐

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, or coveralls, safety glasses and safety footwear. Hard hats, safety glasses and hearing protection will be worn when working near operating equipment.

V. Chemicals of Concern

Chemicals of Concern	Action Level(s)	Response Measures
None anticipated given the nature of activities and limited contact w/ media.		

NOTE: SSO to complete all entries in remaining sections, marking "Yes", "No", or "NA" as appropriate

VI. Additional Safety Equipment/Procedures

Hard-hat .... ☐ Yes ☐ No
Safety Glasses .... ☒ Yes ☐ No
Chemical/splash goggles .... ☐ Yes ☒ No
Splash Shield .... ☐ Yes ☒ No
Splash suits/coveralls.................... ☐ Yes ☒ No
Steel toe Work shoes or boots ...... ☒Yes ☐ No

Hearing Protection (Plugs/Muffs).... ☐ Yes ☐ No
Safety belt/harness.......................... ☐ Yes ☒ No
Radio .... ☐ Yes ☒ No
Barricades .... ☐ Yes ☒ No
Gloves (Type -______________)..... ☐ Yes ☒ No
Work/rest regimen .... ☐ Yes ☒ No

Modifications/Exceptions: Tape up and use insect repellants, wear Tyvek coverall in high brush or wooded areas for further protection against natural hazards (e.g., ticks, poison ivy). If working in areas where snakes are a threat, wear snake chaps to protect against bites.

VII. Procedure review with permit acceptors

	Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐
Procedure for safe job completion	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐
Emergency alarms	☐	☐
Evacuation routes	☐	☐
Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☒
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.)..................... ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Preview work locations to identify potential hazards (slips, trips, and falls, natural hazards, etc.) Avoid potential nesting areas. Wear light colored clothing so that ticks and other biting insects can be easily visible and can be removed. Inspect clothing and body for ticks. Minimize contact with potentially contaminated media. Suspend site activities in the event of inclement weather.

Permit Issued by:______________________________ Permit Accepted by:______________________

SAFE WORK PERMIT FOR
SOIL BORING AND SUBSURFACE SOIL SAMPLING OPRATIONS
AT NWS EARLE COLTS NECK, NEW JERSEY

Permit No. ______________ Date: ________________ Time: From ____________ to ____________

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Soil boring via hollow stem auger

II. Required Monitoring Instruments: FID or PID with 11.3 eV (or higher) lamp source

III. Field Crew: ____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ ____________ TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ (see reverse)
No ☐

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety footwear, and nitrile gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the drill rig or other operating equipment.

V. Chemicals of Concern	Action Level(s)	Response Measures
Chloroform and Methylene chloride	Sustained breathing zone readings > 5.0 ppm	Retreat to an unaffected area Contact the PHSO for guidance.

NOTE: SSO to complete all entries in remaining sections, marking "Yes", "No", or "NA" as appropriate

VI. Additional Safety Equipment/Procedures

	Yes	No		Yes	No
Hard-hat	☒	☐	Hearing Protection (Plugs/Muffs)	☒	☐
Safety Glasses	☒	☐	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☒	Radio	☐	☒
Splash Shield	☐	☒	Barricades	☐	☒
Splash suits/coveralls	☐	☐	Gloves (Type - Nitrile)	☒	☐
Steel toe Work shoes or boots	☒	☐	Work/rest regimen	☐	☒

Modifications/Exceptions: Tyvek coverall if there is a potential for soiling work cloths. PVC or PE coated Tyvek and rubber boots if saturation or work cloths/boots may occur.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: The TtNUS SOPs on Utility Location and Excavation and UXO Clearance will be followed for all subsurface activities. Preview work locations to identify potential hazards (slips, trips, and falls, natural hazards, etc.) Avoid potential nesting areas and use insect repellants (Permanone on clothing and DEET on skin). Wear light colored clothing so that ticks and other biting insects can be easily visible and can be removed. Inspect clothing and body for ticks. Minimize contact with potentially contaminated media. Suspend site activities in the event of inclement weather.

Permit Issued by:______________________________ Permit Accepted by:______________________

SAFE WORK PERMIT FOR GROUNDWATER SAMPLING AT NWS EARLE COLTS NECK, NEW JERSEY

Permit No. ______________ Date: __________________ Time: From ____________ to ______________

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Groundwater sampling.

II. Required Monitoring Instrument(s): FID or PID with 11.3 eV (or higher) lamp source

III. Field Crew: ____

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ TtNUS ______________

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ (see reverse)
No ☐

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety footwear, safety glasses and nitrile gloves. Hard hats and hearing protection will be worn when working near operating equipment and or when required by the facility.

V.

Chemicals of Concern	Action Level(s)	Response Measures
Chloroform and Methylene choloride	Sustained breathing zone readings > 5.0 ppm	Retreat to an unaffected area Contact the PHSO for guidance.

NOTE: SSO to complete all entries in remaining sections, marking "Yes", "No", or "NA" as appropriate

VI. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☐ No
Safety Glasses	☒ Yes	☐ No
Chemical/splash goggles	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☐ No
Steel toe Work shoes or boots	☒ Yes	☐ No
Hearing Protection (Plugs/Muffs)	☐ Yes	☐ No
Safety belt/harness	☐ Yes	☒ No
Radio	☐ Yes	☒ No
Barricades	☐ Yes	☒ No
Gloves (Type - Nitrile)	☒ Yes	☐ No
Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Tyvek coverall if there is a potential for soiling work cloths and PVC or PE coated Tyvek and rubber boots if saturation or work cloths/boots may occur. Reflective vest for high traffic areas. Hearing protection when sampling near operating drill rig.

VII. Procedure review with permit acceptors

	Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐
Procedure for safe job completion	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐
Emergency alarms	☐	☐
Evacuation routes	☐	☐
Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Contaminants were previously detected at low concentrations that are unlikely to present a significant exposure potential (particularly via inhalation). However, air monitoring with FID/PID will be performed as a precautionary measure.

Permit Issued by: ______________________________ Permit Accepted by: ______________________

SAFE WORK PERMIT
DECONTAMINATION ACTIVITIES
NWS EARLE COLTS NECK, NEW JERSEY

Permit No. ______________ Date: __________________ Time: From ____________ to _____________

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Decontamination of sampling equipment and machinery (i.e., drill rigs, augers, excavating equipment, etc.). Brushes and spray bottles will be used to decon small sampling equipment. Pressure washers or steam cleaning units will be used to decon the augers, drill rigs, and other heavy equipment such as the backhoe or excavator.

II. Required Monitoring Instrument(s): FID or PID with 11.3 eV (or higher) lamp source (to screen equipment)

III. Field Crew: ____

IV. On-site Inspection conducted ☒ Yes ☐ No Initials of Inspector ____________ ____________
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ (see reverse)
No ☐

Modifications/Exceptions: Minimum requirement include sleeved shirt and long pants, safety glasses, safety footwear, and nitrile gloves. When using pressure washers, field crews will wear hearing protection, and face shields.

V. Chemicals of Concern	Action Level(s)	Response Measures
Potential site contaminants include VOCs, metals, PCBs, and pesticides	Elevated readings are not anticipated to be encountered	If airborne readings are observed, repeat decon procedure

NOTE: SSO to complete all entries in remaining sections, marking "Yes", "No", or "NA" as appropriate

VI. Additional Safety Equipment/Procedures

Item	Yes	No	Item	Yes	No
Hard-hat	☐	☐	Hearing Protection (Plugs/Muffs)	☒	☐
Safety Glasses	☒	☐	Safety belt/harness	☐	☒
Chemical/splash goggles	☐	☒	Radio	☐	☒
Splash Shield	☒	☐	Barricades	☐	☒
Splash suits/coveralls	☐	☐	Gloves (Type - Nitrile)	☒	☐
Steel toe Work shoes or boots	☒	☐	Work/rest regimen	☐	☒

Modifications/Exceptions: PVC rain suits or PE or PVC coated Tyvek for protection against splashes and overspray. Chemical resistant boot covers if excessive liquids are generated or to protected footwear. Hard hats may be necessary when using a face shield.

VII. Procedure review with permit acceptors

Item	Yes	NA	Item	Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

Item	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Chemical hazards may exist with decontamination procedures given the use of fluids such as isopropyl alcohol, etc. To minimize the potential for exposure, site personnel will use PPE and prevent contact with potentially contaminated equipment. Previous analytical data indicates low concentrations of potential contaminants of concern. Refer to the manufacturer's MSDS regarding PPE, handling, storage, and first-aid measures related to decontamination fluids. Use caution when using pressure washers.

Permit Issued by:______________________________ Permit Accepted by:______________________

SAFE WORK PERMIT FOR
SURVEYING ACTIVITIES
NWS EARLE COLTS NECK, NEW JERSEY

Permit No. ______________ Date: __________________ Time: From ____________ to _____________

SECTION I: General Job Scope

I. Work limited to the following (description, area, equipment used): Surveying and associated activities

II. Required Monitoring Instruments: None

III. Field Crew: ______________________________

IV. On-site Inspection conducted ☐ Yes ☐ No Initials of Inspector ____________ ____________
TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

IV. Protective equipment required
Level D ☒ Level B ☐
Level C ☐ Level A ☐

Respiratory equipment required
Yes ☐ (see reverse)
No ☐

Modifications/Exceptions: Minimum requirements include sleeved shirt and long pants and safety footwear. Safety glasses, hard hats, and hearing protection will be worn when working near operating equipment. Rubber boots or hip waders if activities place personnel in areas of water. Safety glasses and Tyvek if working in brush or wooded areas. Wear insect repellant (Permanone on clothing and DEET on skin)

V. Chemicals of Concern	Action Level(s)	Response Measures
None anticipated given the nature of activities and limited contact w/ media.	None	

NOTE: SSO to complete all entries in remaining sections, marking "Yes", "No", or "NA" as appropriate

VI. Additional Safety Equipment/Procedures

Hard-hat	☐ Yes	☐ No	Hearing Protection (Plugs/Muffs)	☐ Yes	☒ No
Safety Glasses	☐ Yes	☐ No	Safety belt/harness	☐ Yes	☒ No
Chemical/splash goggles	☐ Yes	☒ No	Radio	☐ Yes	☒ No
Splash Shield	☐ Yes	☒ No	Barricades	☐ Yes	☒ No
Splash suits/coveralls	☐ Yes	☐ No	Gloves (Type - Work)	☐ Yes	☐ No
Steel toe Work shoes or boots	☐ Yes	☐ No	Work/rest regimen	☐ Yes	☒ No

Modifications/Exceptions: Tyvek coverall to protect against natural hazards (e.g., ticks). If working in areas where snakes are a threat, wear snake chaps to protect against bites.

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

VII. Procedure review with permit acceptors

	Yes	NA		Yes	NA
Safety shower/eyewash (Location & Use)	☐	☐	Emergency alarms	☐	☐
Procedure for safe job completion	☐	☐	Evacuation routes	☐	☐
Contractor tools/equipment/PPE inspected	☐	☐	Assembly points	☐	☐

VIII. Equipment Preparation

	Yes	No	NA
Utility Locating and Excavation Clearance completed	☐	☐	☐
Equipment and Foot Traffic Routes Cleared and Established	☐	☐	☐
Physical Hazards Barricaded and Isolated	☐	☐	☐
Emergency Equipment Staged	☐	☐	☐

IX. Additional Permits required (Hot work, confined space entry, excavation etc.). ☐ Yes ☒ No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

X. Special instructions, precautions: Preview work locations to identify potential hazards (slips, trips, and falls, natural hazards, etc.) Avoid potential nesting areas. Wear light colored clothing so that ticks and other biting insects can be easily visible and can be removed. Inspect clothing and body for ticks. Minimize contact with potentially contaminated media. Suspend site activities in the event of inclement weather.

Permit Issued by: ______________________ Permit Accepted by: ______________________

ATTACHMENT V

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by all on-site personnel and kept in a central location during the execution of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project ______________________________

Name ______________________________ Home Telephone ____________

Address ______________________________

Age ____________ Height ____________ Weight ____________

Name of Next Kin ______________________________

Drug or other Allergies ______________________________

Particular Sensitivities ______________________________

Do You Wear Contacts?______________________________

Provide a Checklist of Previous Illnesses or Exposure to Hazardous Chemicals ____________

____

____

What medications are you presently using? ______________________________

____

____

Do you have any medical restrictions? ______________________________

____

____

____

Name, Address, and Phone Number of personal physician: ______________________________

____

____

____

I am the individual described above. I have read and understand this HASP.

______________________________ ______________________________

Signature Date

ATTACHMENT VI

TICK / LYME'S DISEASE INFORMATION

**TICK CONTROL
AND
LYME DISEASE**

The occurrence of Lyme disease has become a worldwide problem since its identification in 1976. This disease is characteristically recognized as being transmitted by ticks, which may be encountered by field personnel while working at this site. As a result, this discussion has been included with this Health and Safety Plan to provide for adequate recognition, evaluation, and control efforts to minimize the occurrence and effects of this potential hazard.

The discovery of Lyme disease is credited to Dr. Allen Steere of Yale University Medical School, and is named after the community where it was (reportedly) first encountered, Lyme, Connecticut. This disease can be transmitted to man through the bite of ticks that are infected with a cork screw-shaped microbe (spirochete). The spread of this disease has been so rapid that in 1984 it surpassed Rocky Mountain Spotted fever as the most common tick-borne disease in the United States. In this country, most of the incidents of this disease have been recorded in the Northeast, and the tick species most commonly attributed with its spread is the deer tick.

Recognition

This hazard potential exists primarily in the spring and summer months, as these are the seasons that tick populations and activity flourish. In fact, 90 percent of the reported cases have occurred from early June through September. Also, this concern exists primarily in heavily vegetated areas. Therefore, recognition of these factors can aid in the awareness and control of this threat.

To aid in the recognition and identification of these insects, an example illustration of the tick species common to the region where this site is located has been included with this discussion. This species (the American Dog tick) is common in the eastern half of the United States, and typically exists in areas covered with grass or underbrush. These insects will attach themselves to animals (including man) that pass through the area and rub against them. After finding a host, the tick inserts its mouthparts and sucks blood until it is fully engorged. This requires a time period of three to twelve days, then the tick will drop off. In addition to Lyme disease concerns, this tick has also been identified as a transmitter of Rocky Mountain Spotted Fever, and the organisms of tularemia and possibly relapsing fever. The wounds left by tick bites can be painful, and can also have a paralyzing effect commonly referred to as tick paralysis.

The earliest symptom of the onset of this disease is the occurrence of an unusual red skin rash. This is commonly the first indication since it has been evidenced that many persons who have contracted this disease were, in fact, unaware that they had been bitten. This rash can appear at the site of the bite anywhere from several days to a few weeks after the bite. It typically starts as a small red spot, and then expands as the spirochetes expand from the bite location. Rash sizes can vary, but have been most commonly associated in a 2 to 3 inch diameter size range. This rash will fade (with or without treatment) after a few weeks. Close inspection is necessary to detect this symptom as the rashes are easy to miss because they're often very faint. Body sites where rashes frequently occur include the thigh areas, groin, and armpits. Also, it is not uncommon for a rash to develop in more than one place.

Other early symptoms include profound fatigue, a stiff neck, and flu-like symptoms such as headache, chills, fever, and muscle aches. Recognition of the onset of any of these symptoms is important since tick bites do not always produce a rash. If left untreated, the disease will progress to its second stage within weeks or months after the infection. This stage involves affects to the heart and nervous system. A common second stage symptom is a paralysis on one or both sides of the face. Others include severe headache, encephalitis, or meningitis. The third and final stage involves the development of chronic inflammatory arthritis, which can occur up to a year or more after the bite.

Evaluation

Evaluation of this hazard potential principally involves field personnel performing close self-inspections for the presence of ticks each time they leave the site. This should involve careful examination, especially of the individuals' heads. Personnel should be aware that when a tick attaches itself to its host, it inserts its entire head under the surface of the skin.

Control

Control of this threat involves several components. First, field personnel must be aware of the climate and area conditions which are commonly associated with being conducive to tick infestation. Second, when working in or walking through potential infested areas, personnel must ensure that they do not have exposed body parts (i.e. at least long sleeved shirts and long pants, particularly when protective coveralls are not worn). In heavily vegetated areas where infestation is likely, Tyvek coveralls will be required to minimize this hazard potential. Also, several commercial products have been demonstrated as being effective in repelling ticks. Examples include Permanone, Off!, and Cutter. These types of repellents will be used at the direction and discretion of the Tetra Tech NUS Health and Safety Officer, and only in accordance and observation of manufacturer's recommendations. In most instances, however, such repellents are typically applied to the outside surfaces of clothing (and not directly onto the skin), and should be applied also to shoe tops, socks, pants cuffs, and other areas most susceptible to ticks.

Tick Removal

In the event that a tick is discovered to be attached to a member of the field team, timely removal of the insect is critical to reducing the potential for contracting the disease. According to available information and research, there is apparently a grace period of at least a few hours from the time of the bite before the tick transmits the microbe (the spirochetes are not present in the mouth parts of the tick). However, the incident of a tick bite is frequently unnoticed, and the discovery of the tick may not occur until after this suspected grace period has already elapsed. Therefore, timely removal is very important. The preferred method of tick removal is to pull it out using tweezers or small forceps. In this method, the tick should be grasped as close to the mouth as possible, and then pulled steadily upward. Care must be exercised so as not to pull in a jerking motion as this can result in the head becoming detached. After the tick has been removed, disinfect the bite with rubbing alcohol or povidone iodine (Betadine). The tick must not be handled as the microbes can enter the body through any breaks in intact skin. The bite should be checked occasionally for at least a two-week period to see if a rash forms. If it does, medical attention must be promptly sought.

In order to provide for proper and timely response to the occurrence of a tick bite, the SSO will ensure that the site First Aid kit is properly equipped with medical forceps and rubbing alcohol, in addition to the standard kit contents. Also, an adequate supply of commercial insect (tick) repellents will be maintained on-site, and all personnel will be trained in its proper application and will be required to use it, at the direction of FOL.

APPENDIX B

FIELD FORMS

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: ______________ BORING No.: ______________
PROJECT NUMBER: ______________ DATE: ______________
DRILLING COMPANY: ______________ GEOLOGIST: ______________
DRILLING RIG: ______________ DRILLER: ______________

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION			USCS *	Remarks	PID/FID Reading (ppm)			
					Soil Density/ Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: ______________

Drilling Area Background (ppm): ____

Converted to Well: Yes ____ No ____ Well I.D. #: ______________

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : ______________________ INSTRUMENT NAME/MODEL: ______________________

SITE NAME: ______________________ MANUFACTURER: ______________________

PROJECT No.: ______________________ SERIAL NUMBER: ______________________

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Project Site Name: ____________________
Project No.: ____________________
Sampled By: ____________________
Field Analyst: ____________________
Field Form Checked as per QA/QC Checklist (initials): ____

Sample ID No.: ____________________
Sample Location: ____________________
Duplicate: ☐
Blank: ☐

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	
Method:								

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv): ____________

Electrode Make & Model: ____________________

Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: HACH Digital Titrator OX-DT CHEMetrics (Range: _______mg/L) Analysis Time: ________

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier		Concentration
________	x 0.01	=	mg/L
________	x 0.02	=	mg/L

CHEMetrics: ________mg/L

Notes:

Alkalinity:

Analysis Time: ________

Equipment: HACH Digital Titrator AL-DT CHEMetrics (Range: _______mg/L) Filtered: ☐

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier		Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	_______ & _______	x 0.1	=	mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	_______ & _______	x 0.4	=	mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	_______ & _______	x 1.0	=	mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	_______ & _______	x 2.0	=	mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	_______ & _______	x 5.0	=	mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	_______ & _______	x 10.0	=	mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

CHEMetrics: ________mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:________ Digits Required: 1st.:________ 2nd.:________ 3rd.:________

Carbon Dioxide:

Equipment: HACH Digital Titrator CA-DT CHEMetrics (Range: _______mg/L) Analysis Time: ________

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count			Concentration
________	x 0.1	=	mg/L
________	x 0.2	=	mg/L
________	x 1.0	=	mg/L
________	x 2.0	=	mg/L

CHEMetrics: ________mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:________ Digits Required: 1st.:________ 2nd.:________ 3rd.:________

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Project Site Name: ____________________ Sample ID No.: ____________________

Project No.: ____________________ Sample Location: ____________________

Sampled By: ____________________ Duplicate: ☐

Field Analyst: ____________________ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ☐

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Sulfide (S^{2-}):

Equipment: DR-700 DR-8 __ HS-WR Color Wheel Other: __________ Analysis Time: __________

Program/Module: 610nm 93

Concentration: __________ mg/L Filtered: ☐

Notes: ____________________

Sulfate (SO_4^{2-}):

Equipment: DR-700 DR-8 __ Other: __________ Analysis Time: __________

Program/Module: 91

Concentration: __________ mg/L Filtered: ☐

Standard Solution: ☐ Results: ______

Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______

Notes: ____________________

Nitrite (NO_2^--N):

Analysis Time: __________

Equipment: DR-700 DR-8 __ Other: __________ Filtered: ☐

Program/Module: 60

Concentration: __________ mg/L Reagent Blank Correction: ☐

Standard Solution: ☐ Results: ☐

Notes: ____________________

Nitrate (NO_3^--N):

Analysis Time: __________

Equipment: DR-700 DR-8 __ Other: __________ Filtered: ☐

Program/Module: 55

Concentration: __________ mg/L

Nitrite Interference Treatment: ☐

Standard Solution: ☐ Results: ______ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______

Notes: ____________________

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Project Site Name: ____________________ Sample ID No.: ____________________

Project No.: ____________________ Sample Location: ____________________

Sampled By: ____________________ Duplicate: ☐

Field Analyst: ____________________ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ______

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Manganese (Mn^{2+}):

Equipment: DR-700 DR-8 _ _ HACH MN-5 Other: ____________ Analysis Time: ____________

Program/Module: 525nm 41

Concentration: ____________ mg/L Filtered: ☐

Digestion: ☐

Standard Solution: ☐ Results: ________ Reagent Blank Correction: ☐

Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______

Notes: ____________________

Ferrous Iron (Fe^{2+}):

Equipment: DR-700 DR-8 _ _ IR-18C Color Wheel Other: ____________ Analysis Time: ____________

Program/Module: 500nm 33

Concentration: ____________ mg/L Filtered: ☐

Notes: ____________________

Hydrogen Sulfide (H_2S):

Equipment: HS-C Other: ____________ Analysis Time: ____________

Concentration: ____________ mg/L Exceeded 5.0 mg/L range on color chart: ☐

Notes: ____________________

QA/QC Checklist:

All data fields have been completed as necessary: ☐

Correct measurement units are cited in the SAMPLING DATA block: ☐

Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐

Mulitplication is correct for each *Multiplier* table: ☐

Final calulated concentration is within the appropriate *Range Used* block: ☐

Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐

QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐

Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: ☐

Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: ____________________ **Project No.:** ____________________

Location: ____________________ **Personnel:** ____________________

Weather Conditions: ____________________ **Measuring Device:** ____________________

Tidally Influenced: Yes ____ No ____ **Remarks:** ____________________

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ______________________
Project No.: ______________________

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: ______________________
[] QA Sample Type: ______________________

Sample ID No.: ______________
Sample Location: ______________
Sampled By: ______________
C.O.C. No.: ______________
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

PROJECT NAME: .... WELL/BORING NO.: ....

PROJECT NO.: .... GEOLOGIST: ....

WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....

STATIC WATER LEVEL (Depth/Elevation): .... DATE: ....

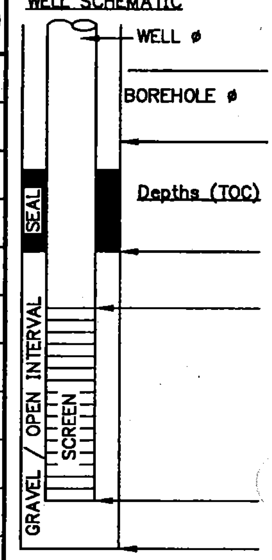
TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....

METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ...... OF ....

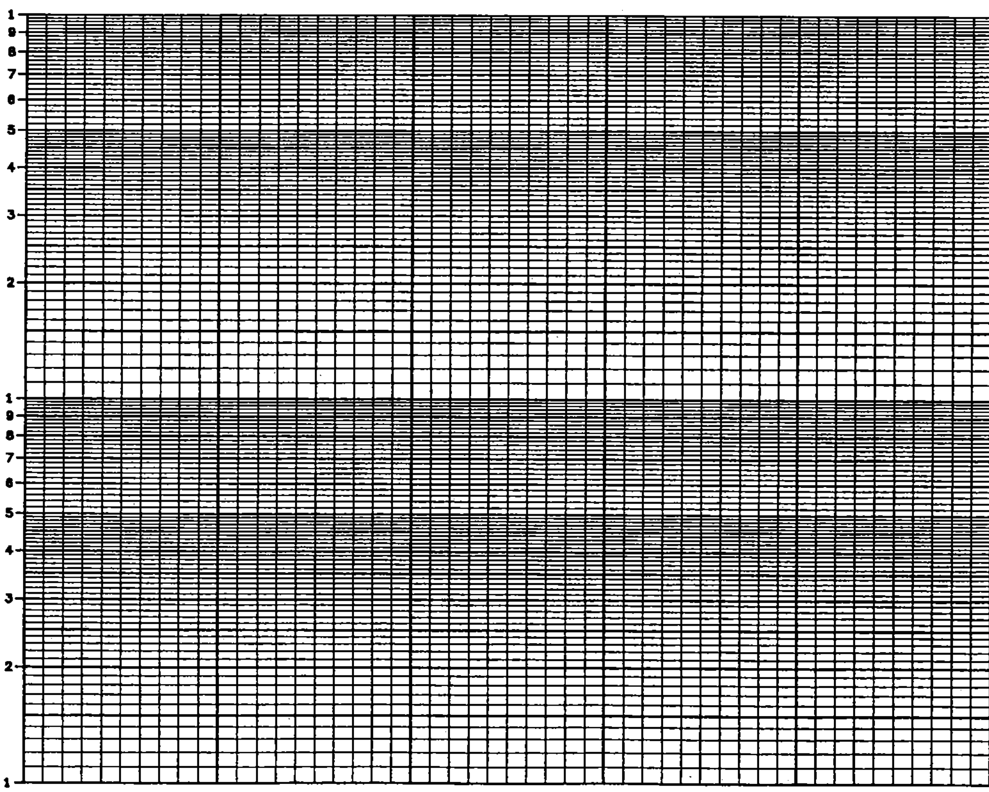
REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): ....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)

WELL SCHEMATIC



▽ Indicate SWL Depth on Drawing



REMARKS:

....

....

....

....

....

....

....

CALCS,SKETCH MAPS, ETC.:

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: ______________________________ WELL ID.: ______________________________

PROJECT NUMBER: ______________________________ DATE: ______________________________

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

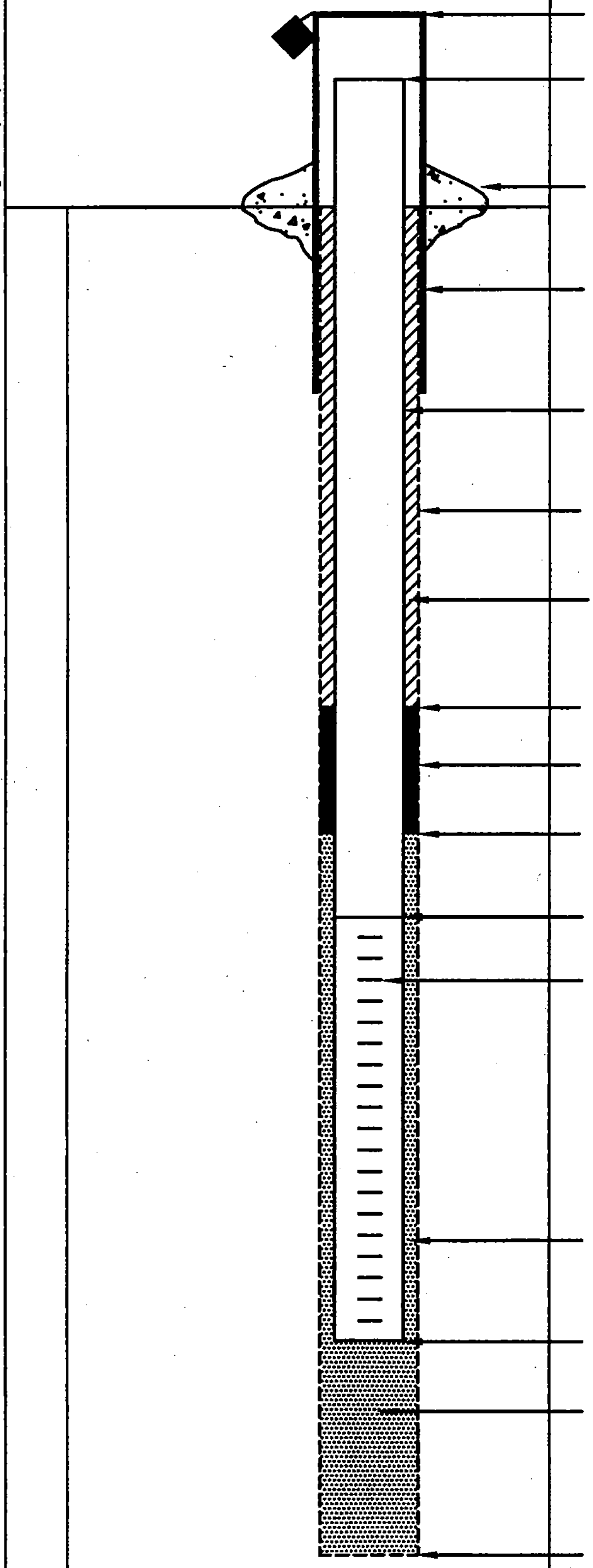
SIGNATURE(S): ______________________________ PAGE___OF___

WELL NO.: ____________

Tetra Tech NUS, Inc.

OVERBURDEN
MONITORING WELL SHEET
STICK-UP

PROJECT ____________	LOCATION ____________	DRILLER ____________
PROJECT NO. ____________	BORING ____________	DRILLING METHOD ____________
DATE BEGUN ____________	DATE COMPLETED ____________	
FIELD GEOLOGIST ____________		DEVELOPMENT METHOD ____________
GROUND ELEVATION ____________	DATUM ____________	



ELEVATION/HEIGHT OF TOP OF SURFACE CASING: ____ / ____

ELEVATION/HEIGHT OF TOP OF RISER PIPE: ____ / ____

TYPE OF SURFACE SEAL: ____________

I.D. OF SURFACE CASING: ____________

TYPE OF SURFACE CASING: ____________

RISER PIPE I.D.: ____________

TYPE OF RISER PIPE: ____________

BOREHOLE DIAMETER: ____________

TYPE OF BACKFILL: ____________

ELEVATION/DEPTH TOP OF SEAL: ____ / ____

TYPE OF SEAL: ____________

DEPTH TOP OF SAND PACK: ____________

ELEVATION/DEPTH TOP OF SCREEN: ____ / ____

TYPE OF SCREEN: ____________

SLOT SIZE x LENGTH: ____________

I.D. OF SCREEN: ____________

TYPE OF SAND PACK: ____________

ELEVATION/DEPTH BOTTOM OF SCREEN: ____ / ____

ELEVATION/DEPTH BOTTOM OF SAND PACK: ____ / ____

BACKFILL MATERIAL BELOW SAND: ____________

ELEVATION/DEPTH OF HOLE: ____ / ____

ACAD: FORM_MWSU.dwg 07/20/99 INL

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Site: ____________________
Well: ____________________
Date Installed: ____________________
Date Developed: ____________________
Dev. Method: ____________________
Pump Type: ____________________

Depth to Bottom (ft.): ____________________
Static Water Level Before (ft.): ____________________
Static Water Level After (ft.): ____________________
Screen Length (ft.): ____________________
Specific Capacity: ____________________
Casing ID (in.): ____________________

Project Name: ____________________
Project Number: ____________________
Site Geologist: ____________________
Drilling Co.: ____________________

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

APPENDIX C

TtNUS STANDARD OPERATING PROCEDURES

TETRA TECH NUS, INC.	# STANDARD OPERATING PROCEDURES	Number: SA-1-1	Page: 1 of 25
		Effective Date: 09/03	Revision: 5
		Applicability: Tetra Tech NUS, Inc.	
		Prepared: Earth Sciences Department	
Subject: GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING		Approved: D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide general reference information regarding the sampling of groundwater wells.

2.0 SCOPE

This procedure provides information on proper sampling equipment, onsite water quality testing, and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, and relative concentrations, and on temperature of measure. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 mS/cm at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode, immersed in water, as referenced against a standard hydrogen electrode.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

Turbidity – Turbidity in water is caused by suspended matter, such as clay, silt, fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES

Project Hydrogeologist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Project Geologist/Field Sample Technician - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field technicians).

5.0 PROCEDURES

5.1 General

To be useful and accurate, a groundwater sample must be representative of the particular zone of the water being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis in order to keep any changes in water quality parameters to a minimum.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach shall be followed prior to sample acquisition:

1. All monitoring wells shall be purged prior to obtaining a sample. Evacuation of three to five volumes is recommended prior to sampling. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical.

2. For wells that can be purged dry, the well shall be evacuated and allowed to recover to 75% full capacity prior to sample acquisition. If the recovery rate is fairly rapid, evacuation of more than one volume of water is required.

3. For high-yielding monitoring wells which cannot be evacuated to dryness, there is no absolute safeguard against contaminating the sample with stagnant water. One of the following techniques shall be used to minimize this possibility:

   - A submersible pump or the intake line of a surface pump or bailer shall be placed just below the water surface when removing the stagnant water and lowered as the water level drops. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. Once this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

   - The intake line of the sampling pump (or the submersible pump itself) unless otherwise directed shall be placed near the center of the screened section, and approximately one casing volume of water shall be pumped from the well at a low purge rate, equal to the well's recovery rate (low flow sampling).

Stratification of contaminants may exist in the aquifer. Concentration gradients as a result of mixing and dispersion processes, layers of variable permeability, and the presence of separate-phase product (i.e., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column as it naturally occurs at that point, thus the result is the collection of a non-representative sample.

5.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with the guidelines expressed in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment - Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler, ice, labels and chain-of-custody documents.

- Field tools and instrumentation - Multi-parameters water quality meter capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity and salinity or individual meters (as applicable), pH paper, camera and film (if appropriate), appropriate keys (for locked wells), water level indicator.

- Pumps

  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.

- Other sampling equipment - Bailers and inert line with tripod-pulley assembly (if necessary).

- Pails - Plastic, graduated.

- Decontamination solutions - Deionized water, potable water, laboratory detergents, 10% nitric acid solution (as required), and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.3 Calculations of Well Volume

To insure that the proper volume of water has been removed from the well prior to sampling it is first necessary to know the volume of standing water in the well pipe. This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form (see SOP SA-6.3):

- Obtain all available information on well construction (location, casing, screens, etc.).

- Determine well or inner casing diameter.

- Measure and record static water level (depth below ground level or top of casing reference point).

- Determine depth of well by sounding using a clean, decontaminated, weighted tape measure.

- Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

- Calculate one static well volume in gallons $V = (0.163)(T)(r^2)1$

where:		
V	=	Static volume of well in gallons.
T=		Thickness of water table in the well measured in feet (i.e., linear feet of static water).
r	=	Inside radius of well casing in inches.
0.163	=	A constant conversion factor which compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi.

- Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

5.4 Evacuation of Static Water (Purging)

5.4.1 General

The amount of purging a well shall receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately the well can be pumped until the parameters such as temperature, specific conductance, pH, and turbidity (as applicable), have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook, field notebook, or on standardized data sheets.

5.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. Note that all of these techniques involve equipment which is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Bailers are inexpensive, and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause significant loss of dissolved gases and volatile organics.

Air-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Air (or gas)-lift samplers are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation, or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- They may have low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time-consuming.

5.5 **Onsite Water Quality Testing**

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance
- Temperature
- Dissolved Oxygen (DO)
- Oxidation-Reduction Potential (ORP)

- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, and colloidal material or suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP 6.3 for example equipment calibration log.

5.5.1 Measurement of pH

5.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required, and the pH meter when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

5.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific pH range hydrion paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion concentration across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

5.5.1.3 Equipment

The following equipment is needed for taking pH measurements:

- Stand-alone portable pH meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

- Combination electrode with polymer body to fit the above meter (alternately a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs).

- Buffer solutions, as specified by the manufacturer.

- pH indicator paper, to cover the pH range 2 through 12.

- Manufacturer's operation manual.

5.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure is used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

- Inspect the instrument and batteries prior to initiation of the field effort.

- Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.

- If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

- Calibrate on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on an equipment calibration log sheet.

- Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

- Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH unit. Also record the sample temperature.

- Rinse the electrode(s) with deionized water.

- Store the electrode(s) in an appropriate manner when not in use.

Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is adequately determined.

5.5.2 Measurement of Specific Conductance

5.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance. Most conductivity meters in use today display specific conductance (SC); units of milliSiemens per centimeter, which is the conductivity normalized to temperature @ 25°C. This format (SC) is the required units recorded on the groundwater sample log field form (Attachment B).

5.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, while the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.5.2.3 Equipment

The following equipment is needed for taking specific conductance (SC) measurements:

- Stand alone portable conductivity meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available which may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirement of the sampling program.

5.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet. Potassium chloride solutions with a SC closest to the values expected in the field shall be used for calibration.
- Rinse the cell with one or more portions of the sample to be tested or with deionized water.
- Immerse the electrode in the sample and measure the conductivity.
- Read and record the results in a field logbook or sample log sheet.
- Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for details.

5.5.3 Measurement of Temperature

5.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

5.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.
- Record values in a field logbook or sample log sheet.

If a temperature meter or probe is used, the instrument shall be calibrated according to manufacturer's recommendations.

5.5.4 Measurement of Dissolved Oxygen

5.5.4.1 General

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible, and is not susceptible to interference caused by color, turbidity, colloidal material or suspended matter.

5.5.4.2 Principles of Equipment Operation

Dissolved oxygen probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, while leaving the surface of the solution undisturbed.

Dissolved oxygen probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide, which are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field log book and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer.

5.5.4.3 Equipment

The following equipment is needed to measure dissolved oxygen concentration:

- Stand alone portable dissolved oxygen meter, or combination meter (e.g., Horiba U-10), or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

5.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration:

- The equipment shall be calibrated and have its batteries checked before going to the field.
- The probe shall be conditioned in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
- The instrument shall be calibrated in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
- Record all pertinent information on an equipment calibration sheet.
- Rinse the probe with deionized water.
- Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells can be moved up and down.
- Record the dissolved oxygen content and temperature of the sample in a field logbook or sample log sheet.
- Rinse the probe with deionized water.
- Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This however, may not always be practical.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen solubilization and positive test interferences.

5.5.5 Measurement of Oxidation-Reduction Potential

5.5.5.1 General

The oxidation-reduction potential (ORP) provides a measure of the tendency of organic or inorganic compounds to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of oxidized to reduced species in the sample.

5.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as dissolved oxygen, may be correlated with ORP to provide a knowledge of the quality of the solution, water, or wastewater.

5.5.5.3 Equipment

The following equipment is needed for measuring the oxidation-reduction potential of a solution:

- Combination meters with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring oxidation-reduction potential:

- The equipment shall be checked using the manufacturer's recommended reference solution and have its batteries checked before going to the field.

- Thoroughly rinse the electrode with deionized water.

- If the probe does not respond properly to the recommended reference solution, then verify the sensitivity of the electrodes by noting the change in millivolt reading when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease if the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note the ORP drops sharply when the caustic is added (i.e., pH is raised) thus indicating the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

- Record all pertinent information on an equipment calibration log sheet.

5.5.6 Measurement of Turbidity

5.5.6.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and microscopic organisms, including plankton.

It is important to obtain a turbidity reading immediately after taking a sample, since irreversible changes in turbidity may occur if the sample is stored too long.

5.5.6.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method. This method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidmeter. Therefore, nephelometric turbidity units (NTU) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

5.5.6.3 Equipment

The following equipment is needed for turbidity measurement:

- Light meter (e.g., LaMotte 2020) which calibrates easily using test cells with standards of 0.0 NTUs, and 10 NTUs, or combination meter (e.g., Horiba U-10), or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.6.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate instrument before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the electrode with one or more portions of the sample to be tested or with deionized water (applies to "e").
- Fill the light meters glass test cell with ~5 ml of sample, screw on cap, wipe off glass, place test cell in light meter and close the lid (applies to "l").
- Immerse the electrode in the sample and measure the turbidity (applies to "e").
- The reading must be taken immediately as suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
- Read and record the results in a field logbook or sample log sheet. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
- Rinse the electrode or test cell with deionized water.

5.5.7 Measurement of Salinity

5.5.7.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Note: Most field meters determined salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or % (e.g., 35 ppt will equal 3.5%).

5.5.7.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (found in *Standard methods for the Examination of Water and Wastewater*). Depending on the meter, the results are displayed in either ppt or %. The salinity measurements are carried out in reference to the conductivity of standard seawater (*corrected to S = 35*).

5.5.7.3 Equipment

The following equipment is needed for Salinity measurements:

- Multi-parameter water quality meter capable of measuring conductive, temperature and converting them to salinity (e.g., Horiba U-10 or YSI 600 series).
- Calibration Solution, as specified by the manufacturer.
- Manufacturer's operation manual.

5.5.7.4 Measurement Techniques for Salinity

The steps involved in taking Salinity measurements are listed below (standardization is according to manufacturer's instructions):

- Check batteries and calibrate before going into the field.
- Check the expiration date (etc.) of the solutions used for field calibration.
- Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on an equipment calibration log sheet.
- Rinse the cell with the sample to be tested.
- Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or sample log sheet.
- Rinse the probes with deionized water.

5.6 Sampling

5.6.1 Sampling Plan

The sampling approach consisting of the following, shall be developed as part of the project plan documents which are approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

- Sample preservation requirements.

- Work schedule.

- List of team members.

- List of observers and contacts.

- Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.6.2 Sampling Methods

The collection of a groundwater sample consists of the following steps:

1. The site Health & Safety Officer (or designee) will first open the well cap and use volatile organic detection equipment (PID or FID) on the escaping gases at the well head to determine the need for respiratory protection.

2. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet (see Attachment B); then calculate the fluid volume in the well pipe (as previously described in this SOP).

3. Calculate well volume to be removed as stated in Section 5.3.

4. Select the appropriate purging equipment (see Attachment A). If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower the purging equipment or intake into the well to a short distance below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (as applicable). Lower the purging device, as required, to maintain submergence.

6. Measure the rate of discharge frequently. A graduated bucket or cylinder and stopwatch are most commonly used.

7. Observe the peristaltic pump intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

8. Purge a minimum of three to five casing volumes before sampling. In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Purged water shall be collected in a designated container and disposed in an acceptable manner.

9. If sampling using a pump, lower the pump intake to midscreen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

10. (For pump and packer assembly only). Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

11. In the event that recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this occurrence in the site logbook.

12. Fill sample containers (preserve and label as described in SOP SA-6.1).

13. Replace the well cap and lock as appropriate. Make sure the well is readily identifiable as the source of the samples.

14. Process sample containers as described in SOP SA-6.1.

15. Decontaminate equipment as described in SOP SA-7.1.

5.7 Low Flow Purging and Sampling

5.7.1 Scope & Application

Low flow purging and sampling techniques are sometimes required for groundwater sampling activities. The purpose of low flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. The minimum stress procedure emphasizes negligible water level drawdown and low pumping rates in order to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen, or open interval, length of ten feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This procedure is not designed to collect non-aqueous phase liquids samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs), using the low flow pumps.

The procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTU and to achieve a water level drawdown of less than 0.3 feet during purging and sampling. If these goals cannot be achieved, sample collection can take place provided the remaining criteria in this procedure are met.

5.7.2 Equipment

The following equipment is required (as applicable) for low flow purging and sampling:

- Adjustable rate, submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).
- Disposable clear plastic bottom filling bailers may be used to check for and obtain samples of LNAPLs or DNAPLs.

- Tubing - Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.

- Water level measuring device, 0.01 foot accuracy, (electronic devices are preferred for tracking water level drawdown during all pumping operations).

- Interface probe, if needed.

- Flow measurement supplies.

- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.

- Indicator parameter monitoring instruments - pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional Indicators - ORP, salinity, and dissolved oxygen, flow-through cell is required. Standards to perform field calibration of instruments.

- Decontamination supplies.

- Logbook(s), and other forms (see Attachments B and C).

- Sample Bottles.

- Sample preservation supplies (as required by the analytical methods).

- Sample tags and/or labels.

- Well construction data, location map, field data from last sampling event (if available).

- Field Sampling Plan.

- PID or FID instrument for measuring VOCs (volatile organic compounds).

5.7.3 Purging and Sampling Procedure

Open monitoring well, measure head space gases using PID/FID. If there is an indication of off gassing when opening the well, wait 3-5 minutes to permit water level an opportunity to reach equilibrium.

Measure and record the water level immediately prior to placing the pump in the well.

Lower pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is three feet or less of standing water in the well.

Start with the initial pump rate set at approximately 0.1 liters/minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 feet during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters/minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging will cease or the well will be pumped to dryness and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be colleted from these wells within the same workday and no later than 24 hours after the start of purging.

Measure the well water level using the water level meter every 5 to 10 minutes. Record the well water level on the Low-Flow Purge Data Form (Attachment C).

Record on the Low-Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, dissolved oxygen and salinity or as specified by the approved site specific work plan) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

After stabilization is achieved, sampling can begin when a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits:

- pH ±0.2 standard units
- Specific conductance ±10%
- Temperature ±10%
- Turbidity less than 10 NTUs
- Dissolved oxygen ±10%

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form.

VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples: (1) Collect the non-VOCs samples first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample and record the new flow rate; (2) reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel), or clamp which should reduce the flow rate by constricting the end of the tubing; (3) insert a narrow diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, collect sample from the narrow diameter tubing.

Prepare samples for shipping as per SOP SA-6.1.

6.0 REFERENCES

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U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
SS	Stainless steel
PC	Polycarbonate
EPDM	Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA	Not applicable
AC	Alternating current
DC	Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: ____________
[ ] QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:	Signature(s):

ATTACHMENT C
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: ____________________ WELL ID.: ____________________
PROJECT NUMBER: ____________________ DATE: ____________________

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): ____________________ PAGE___OF___

TABLE OF CONTENTS

SECTION **PAGE**

ATTACHMENTS

1.0 PURPOSE

The purpose of this document is to provide general reference information regarding natural attenuation parameter and methodology selection, sample collection, and a general understanding of the sample results.

2.0 SCOPE

This document provides information on selection of appropriate groundwater natural attenuation parameters, selection of sampling methods for these parameters, techniques for onsite field analysis of select parameters, and some basic understanding of the field sample results. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling practices and techniques. To a limited extent, it shall also facilitate the understanding and interpretation of the sampling results. It addresses field procedures for collection of data at sites with organic groundwater contaminants (e.g., chlorinated and petroleum hydrocarbons) to the extent practical. The focus of this document is on natural attenuation, not enhanced bioremediation.

The techniques described shall be followed whenever applicable, noting that site-specific conditions, project-specific objectives, local, state, and federal guidelines may be used as a basis for modification of the procedures noted herein. The intent of this document is to supplement the local, state, and federal guidance documents and manufacturer's analytical methods referenced in Section 6.0. It is not intended for this document to supersede this guidance or information. Please note that natural attenuation is a relatively dynamic science with ongoing research in the science and engineering community. It is important that data collectors and interpreters use the most recent regulatory guidance, which may be updated on a periodic basis from that noted in Section 6.

3.0 GLOSSARY

Aerobe: Bacteria that use oxygen as an electron acceptor.
Anaerobe: Organisms that can use electron acceptors other than molecular oxygen to support their metabolism.
Anoxic groundwater: Groundwater that contains oxygen in concentrations less than about 0.5 mg/L. This term is synonymous with the term anaerobic.
Anthropogenic: Man-made.
Cometabolism: The process in which a compound is fortuitously degraded by an enzyme or cofactor produced during microbial metabolism of another compound.
Daughter product: A compound that results directly from the biotic or abiotic degradation of another. For example, *cis*-1,2-dichloroethene (*cis*-1,2-DCE) is a common daughter product of trichloroethene (TCE).
Diffusion: The process whereby molecules move from a region of higher concentration to a region of lower concentration as a result of Brownian motion.
Dispersion: The tendency for a solute to spread from the path that it would be expected to follow under advective transport.
Electron acceptor: A compound capable of accepting electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an electron acceptor. Electron acceptors are compounds that are relatively oxidized and include oxygen, nitrate, iron(III), manganese(IV), sulfate, carbon dioxide, or in some cases chlorinated aliphatic hydrocarbons such as tetrachloroethene (PCE), TCE, DCE and vinyl chloride (VC).
Electron donor: A compound capable of supplying (giving up) electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an

electron acceptor. Electron donors are compounds that are relatively reduced and include fuel hydrocarbons and native organic carbon.

Metabolic byproduct: A product of the reaction between an electron donor and an electron acceptor. Metabolic byproducts include volatile fatty acids, daughter products of chlorinated aliphatic hydrocarbons, methane, and chloride.

Oxic groundwater: Groundwater that contains oxygen in concentrations greater than about 0.5 mg/L.

Oxidation/reduction reaction: A chemical or biological reaction wherein an electron is transferred from an electron donor (donor is oxidized) to an electron acceptor (acceptor is reduced).

Predominant terminal electron-accepting process: The electron-accepting process (oxygen reduction, nitrate reduction, iron(III) reduction, etc.) that sequesters the majority of the electron flow in a given system.

Reductive dechlorination: Reduction of a chlorine-containing organic compound via the replacement of chlorine with hydrogen.

Respiration: The process of coupling the oxidation of organic compounds with the reduction of inorganic compounds such as oxygen, nitrate, iron(III), manganese(IV), and sulfate.

Seepage velocity: The average velocity of groundwater in a porous medium.

Substrate: A compound used by microorganisms to obtain energy for growth. The term can refer to either an electron acceptor or an electron donor.

4.0 RESPONSIBILITIES

Project Manager (PM) / Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this standard operating procedure (SOP).

Project Hydrogeologist or Geochemist - Responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), and equipment to be used, and providing detailed input in this regard to the project plan documents. The project hydrogeologist or geochemist is also responsible for properly briefing and overseeing the performance of the site sampling personnel.

Site Manager (SM) / Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field sampling technicians or site personnel).

5.0 PROCEDURES

5.1 General

Natural attenuation includes physical, chemical, and biochemical processes affecting the concentrations of dissolved contaminants in groundwater. These processes may include advection, dispersion, volatilization, dilution, sorption to aquifer solids, and/or precipitation or mineralization of compounds. Of greatest importance are those processes that lead to a reduction in contaminant mass (by degrading or destroying contaminants) such as biodegradation. These biochemical processes remove organic contaminants from the aquifer by destruction. Depending on the type of contaminant, particularly the organic contaminant (e.g., petroleum hydrocarbons or chlorinated organic solvents), the biochemical environment in the aquifer will vary. The biochemical environment within the aquifer influences and is influenced by the activities of aquifer microbiota. Specific types of microbiota, working singly or in complex consortia, may use organic contaminants as part of their normal cell functions. Natural attenuation monitoring is designed to measure indicators of the biochemical environment within the aquifer and, with direct and indirect lines of evidence and associated chemical concentration data, evaluate the likely fate (i.e., transformation, destruction, dilution, attenuation, etc.) of organic contaminants.

5.2 Planning for Natural Attenuation Sampling

The first step in preparing a natural attenuation investigation is to develop a site-specific conceptual model. The first step in development of this model is the analysis and review of available site-specific characterization data. The development and refinement of this model should be supplemented with additional data as needed. The data should include but is not limited to:

- Geologic and hydrogeologic information in three dimensions
- Nature, extent, and magnitude of contamination
- Location and presence of potential receptors to contamination

Lines of Evidence

Several lines of evidence are used to determine whether natural attenuation is working. The most compelling, primary evidence is decreasing groundwater contaminant concentrations over time. Decreasing concentration trends can be demonstrated in several ways including:

- Isoconcentration maps of the dissolved plume over time wherein the extent of the plume is either stable or decreasing.
- Time series plots of contaminant concentrations within a well illustrating a clear downward trend.
- Contaminant concentration profiles in a series of monitoring wells along a groundwater flow path illustrating decreasing concentrations beyond that attributable to dilution and dispersion.

Secondary, or supporting, lines of evidence include:

- Analytical data showing production and subsequent destruction of primary contaminant breakdown products.
- Geochemical data indicating that the biochemical environment is favorable for the appropriate microbiota.
- Geochemical data that indicate the aquifer microbiota are active.

Monitoring Well Location and Sampling Frequency

The number and locations of wells required to monitor natural attenuation will depend on the physical setting at each location. One possible array of monitoring wells is illustrated in Attachment A. In this scenario, one well is used to monitor conditions upgradient of the source, one well is located in the source area, and several wells are used to define and monitor the downgradient and lateral extent of the dissolved plume. At a minimum, there should be at least one upgradient well (ideally with no contamination present), one well in the source area, one well downgradient from the source area in the dissolved plume, and one downgradient well where contaminant concentrations are below regulatory criteria. Note that the number and locations of monitoring wells will vary depending on the site complexity and site objectives.

Sampling frequency will be dictated by the ultimate use of the data and site-specific characteristics. Contaminant concentrations may be used to define statistically meaningful trends in contaminant concentrations. The sampling frequency may be defined by the hydrogeologic and/or geochemical conditions as well as the proposed statistical method for data analysis. For example, groundwater flow and contaminant characteristics (e.g., seepage velocity and contaminant loading) may dictate the sample frequency. Regardless of the factors, sampling frequency and duration will need to establish the range of natural chemical variability within the aquifer. After a sufficient amount of data has been collected and the geochemical conditions are understood, the frequency of sampling may be reduced. See Section 5.4 for additional information on sample collection and frequency.

5.3 Selection of Natural Attenuation Parameters

Natural attenuation via biodegradation depends on the nature of the organic contaminants and the oxidation-reduction (redox) environment within the aquifer. Simply stated, if the contaminants are fuels, biodegradation will be most effective if the redox conditions are aerobic or oxidizing. If the contaminants are chlorinated solvents, the biodegradation will be most effective (in the source and near source areas) if redox conditions in the aquifer are anaerobic or reducing.

Several parameters are needed to evaluate whether natural attenuation is taking place and, if so, the rate at which it may be occurring. The primary parameter providing direct evidence of natural attenuation is the aqueous concentrations of parent and daughter volatile organic compounds. More specifically, a decrease in percent products, an increase in daughter products, evidence that the plume is stable or shrinking in size, and overall decline in contaminant concentrations is direct evidence of natural attenuation. Natural attenuation or geochemical parameters that provide information about the redox conditions in the aquifer include:

- Dissolved oxygen
- Nitrate/nitrite
- Dissolved manganese
- Iron
- Sulfate/sulfide
- Methane
- Oxidation-reduction potential (ORP)

Secondary parameters that indicate biological activity in the aquifer and thereby support the natural attenuation evaluation include:

- Dissolved hydrogen
- Alkalinity
- Dissolved carbon dioxide

The concentrations of natural attenuation parameters are used to define the aquifer redox conditions. It is important to record and document the presence or absence (i.e., measurable or not measurable concentration) of certain natural attenuation parameters. The presence or absence of a certain substance may be sufficient to indicate the redox condition within the aquifer. By reference to Attachment B, which illustrates the typical sequence of biologically mediated redox reactions in natural systems, it is apparent that, for example, sulfate reduction (producing dissolved sulfide in groundwater) does not operate in an aerobic environment. Therefore, measurable sulfide should not be present if there is also dissolved oxygen at concentrations indicating an aerobic environment. Attachment B also illustrates the redox potential (measured in millivolts) associated with the redox reactions. ORP readings, also in millivolts, measured during well purging, may be compared with the range of values in Attachment B but with caution. Redox potentials measured with a platinum electrode in natural water samples may be misleading, especially when biologically mediated reactions are important, because many of the critical reactions in Attachment B do not generate a response in the electrode. Dissolved hydrogen concentration ranges associated with important redox reactions are also indicated in Attachment B. Because dissolved hydrogen is actually used by microbiota during redox reactions, its concentration may provide an additional indicator of the overall redox condition in the aquifer.

Attachments C and D tabulate the natural attenuation parameters for chlorinated volatile organic compound and petroleum hydrocarbon plumes, respectively. The parameters listed in these tables are organized in order of importance. Parameters selected for analysis shall be determined based on site conditions, project-specific plans, and/or other criteria established for the project. Based on these criteria, it is possible that all of the parameters may be selected.

5.4 Selection of Natural Attenuation Analytical Methods and Procedures

There are many analytical methods available to measure concentrations of the natural attenuation parameters discussed in the previous sections. Attachment E summarizes the sample methodologies, sampling equipment needed, sample volume, container, preservation, and holding time requirements. This table also summarizes the detection limits and the detection ranges for each method. A number of factors should be considered when selecting the appropriate sample analytical methodology including the required parameters, appropriate detection ranges for each compound, cost, and ease of use in the field. For example, when determining the correct methodology for measuring concentrations of total sulfide, the metabolic byproduct of sulfate reducing conditions, it is important to analyze for each of the forms of sulfide (H_2S, S^{-2}, and HS^-). Also, when the detection limit of the selected method is exceeded, another method may be considered, or the sampler may be able to dilute the sample (per manufacturer's instructions) to quantify it within the detected range. In terms of cost, some parameters are very time consuming when performed in the field. Without sacrificing sample integrity it may be more appropriate to select a methodology performed in a fixed-base laboratory. Finally, in terms of ease of use, certain field methods are generally easier compared to other methods. Using simpler methods may result in better quality sample results and increased sample repeatability without sacrificing sample integrity. For example, in some cases CHEMetrics Titret® Titration Ampule kits may be a good alternative to other hand digital titration methods.

The sample technicians should be aware that based on geochemical conditions recorded in the field, certain geochemical parameters may not have positive detections. For example, if dissolved oxygen concentrations indicate aerobic conditions then it is unlikely that dissolved hydrogen is present (see Section 5.10 for additional information). Another example is alkalinity. If the pH of the groundwater sample is less than 4.5, then it is unlikely that alkalinity will be measurable. Despite the potential for non-detect results, in cases such as those described above, all parameters should be collected in the field based upon project plans. The value in collecting the parameters in the future shall be determined by the project hydrogeologist and/or geochemist in accordance with the projects planning documents data quality objectives (DQO) and the items discussed in Section 5.2.

5.5 Procedures for Sample Collection

Groundwater sample collection for natural attenuation sampling should be performed using low flow purging and sampling techniques. These techniques are described in detail in SOP SA-1.1. Low flow purging and sampling procedures should be used to ensure the collection of a sample that is "representative" of the water present in the aquifer formation. Minimizing stress on the aquifer formation during low flow purging and sample collection ensures that there are minimal alternations to the water chemistry of the sample. The criteria used in the purging process should include minimization of drawdown in the well, stabilization of applicable indicator parameters, and evacuation of a sufficient amount of purge volume in accordance with SOP SA-1.1, project plans, and/or applicable regulatory guidance.

Groundwater purging and sampling for natural attenuation should be performed using submersible pumps (e.g., bladder pumps) in accordance with SOP SA-1.1. However, in accordance with project plans and applicable regulatory guidance, peristaltic pumps may also be used for this purpose. Limitations of and factors associated with using these devices should be considered (see SOP SA-1.1 for more information). As a result of difficulties in collecting "representative" groundwater samples, bailers should not be used for the collection of natural attenuation samples.

It is critical that disturbance and aeration of samples monitored and collected at the well head are minimized. As a result, a flow-through sampling cell and a direct reading meter shall be used for the measurement of well stabilization indicator parameters (e.g., pH, conductivity, temperature, dissolved oxygen, turbidity, and ORP) at the well head. The pump effluent tubing should be placed at the bottom of the flow-through cell allowing effluent water from the cell to discharge at the top of the meter (above the detector probes) to minimize the agitation of water in the cell.

Documentation of the purging process shall be recorded during and at the completion of purging as discussed in Section 5.8. Immediately following the purging process and before sampling, all applicable indicator parameters must be measured and recorded on the appropriate sample log sheets as discussed in Section 5.8.

After all of the purging requirements have been met, groundwater sampling and natural attenuation data collection can begin. Monitoring wells will be sampled using the same pump and tubing used during well purging.

5.6 Procedures for Field Sample Analysis

Each of the field and fixed-base laboratory sample parameters requires different sampling procedures and holding times. Attachment E presents parameter-specific requirements for sampling, analysis, and storage of all of the parameters and methods sampled as part of natural attenuation analysis.

Due to parameter procedure and holding times, it is important to consider the sequence of sample collection and analysis. Generally speaking, with the exception of volatile organic compounds, field parameters shall be analyzed first followed by fixed-base laboratory sample collection. All samples will be collected in a sequence and manner that minimizes volatilization, oxidation, and/or chemical transformation of compounds. As a result, the following sample and analysis order should be followed:

1. Volatile organic compounds
2. Dissolved oxygen
3. Alkalinity
4. Dissolved carbon dioxide
5. Dissolved ferrous iron
6. Dissolved sulfide (hydrogen sulfide and sulfide)
7. Dissolved hydrogen, methane, ethene, and ethane
8. Nitrate / Nitrite
9. Dissolved manganese
10. Semivolatile organic compounds
11. Other dissolved metals
12. Total metals
13. All other constituents

Field-analyzed parameters should be collected and immediately analyzed directly from the pump effluent per the requirements on Attachment E and manufacturer's recommendations. Care should be taken to minimize any unnecessary disturbance, aeration, or agitation of the sample prior to analysis. It is not acceptable to collect and store samples that are to be analyzed immediately at the well head in a temporary holding container (e.g., open topped pitcher) to be analyzed at a later time.

The manufacturer's procedure manual for each of the field-based analyses shall be maintained in the field during the entire sampling program. The procedures give a detailed explanation of how to perform each particular method and include information on sampling, storage, accuracy checks, interferences, reagents, and apparatus needed to perform each analysis.

5.7 Procedures for Quality Assurance and Quality Control Field Sample Analysis

Accuracy and precision checks shall be performed to check the performance of the reagents, apparatus, and field analytical procedures per the manufacturer's recommendations. The accuracy checks should include the use of standard solutions (i.e., standard addition), as appropriate. The manufacturer's field test kit manual provides details on how to perform each of the accuracy checks for each parameter where applicable. Refer to Section 6.0 for manufacturer contact information.

Precision checks must include the performance of duplicate analysis. When using a colorimeter, precision checks may also include reagent blank corrections and standard curve adjustments as recommended by the manufacturer. Field duplicate results shall be performed and evaluated for relative percent difference (RPD) at a rate of 1 per 10 samples or as determined by the project plans. The RPD can be calculated as follows:

$$RPD = \left| \frac{\text{First result - Second result}}{\text{Mean arithmetic (average) of first and second result}} \right| \times 100$$

If the RPD exceeds 50 percent, it is required that the test be performed again to verify the result. The duplicate results shall be documented in the 'Notes' section for that specific parameter on the appropriate sample logsheet (see Section 5.8).

If a colorimeter (e.g., HACH DR-890 or equivalent) is used for parameter analysis, an instrument performance verification test using absorbance standards may also be performed to ensure the meter is providing accurate measurements.

The following table lists examples of the types and frequencies of accuracy checks required for each parameter. Refer to the manufacturer's instructions for information regarding other analyses.

Parameter	Method	Standard Solution	Field Duplicate	Reagent Blank Correction
Alkalinity	CHEMetrics K-9810, -15, -20	None	1 per 10	None
Carbon dioxide	CHEMetrics K-1910, -20, -25	None	1 per 10	None
Dissolved oxygen	CHEMetrics K-7501, -12	None	1 per 10	None
Ferrous iron	HACH DR-890	None	1 per 10	None
Nitrite	HACH DR-890	1 per round	1 per 10	1 per lot
Nitrate	HACH DR-890	1 per round	1 per 10	1 per lot
Sulfide	HACH DR-890	None	1 per 10	None
Hydrogen sulfide	HACH HS-C	None	1 per 10	None

Prior to analysis, the expiration dates of reagents shall be checked. If the reagents have exceeded their expiration date or shelf life, the reagents shall be replaced. If deviations from the applicable analytical procedure are identified, the deviations shall be corrected and the associated samples re-analyzed. If problems are identified with the reagents, apparatus, or procedures, data interferences may be present. Interferences may also be due to other factors (e.g., pH, presence or concentration of other ions, turbidity, temperature, etc.) that may interfere with the sample result. The manufacturer's procedures (e.g., Hach, 1999) should be reviewed prior to analysis to avoid or minimize such interferences. Associated problems or suspected interferences shall be documented in the 'Notes' section of the sample logsheet. Often, interferences cannot be avoided. In these cases, the sampler should be aware of these potential interferences and document them properly.

5.8 Documentation Procedures for Field Sample Analysis

Field results shall be properly documented in the field as noted in SOP SA-6.3. The sample log sheet titled "Field Analytical Log Sheet, Geochemical Parameters" shall be prepared for each sample collected and analyzed in the field. A copy of this form can be found as Attachment F of this SOP. Other field log sheets (e.g., low flow purge log sheet, groundwater sample logsheet, etc.) shall also be completed in accordance with SOP SA-6.3.

Specific information shall also be recorded in the project logbook. This information shall include, but is not limited to, the test kit name and model number, lot number and expiration date of the test kit and reagents used, serial number of the instrument (e.g., colorimeter) used for the analysis, and results of the quality assurance and quality control field sample analysis. Because environmental conditions and changes in those conditions may affect the field analytical results, it is important to document the site conditions (weather, temperature, etc.) at the time of sampling in the logbook in accordance with SOP SA-6.3.

5.9 Waste Handling and Disposal

Several of the test kits listed in Attachment E require the use of chemicals and materials that must be properly handled and disposed of in a proper and responsible manner. Refer to specific manufacturer's guidance for handling and disposal practices. See also Section 6.0 for more detailed and complete information. Handling and disposal of these items should be conducted in accordance with all local, state, and federal guidelines.

5.10 Understanding Field Sample Analytical Results

Natural attenuation data interpretation is complicated by the complex inter-relationships of various parameters. The complexity reflects the myriad of biochemical processes. Real-time evaluation of field analytical data can be misleading because a full interpretation often requires combining the field analytical results with fixed-base laboratory results. Regardless, some simple observations and data interpretations in the field may provide insights about the monitoring system or early warnings about sample collection and handling problems.

Data collected from the designated upgradient monitoring well is the baseline from which other interpretations are made. Field analytical data will indicate that the upgradient environment is either oxidizing or reducing. The redox condition within the upgradient area of the aquifer may be natural or impacted by other contaminant source areas (see Section 5.2 for upgradient well selection). Regardless, the redox condition of the upgradient groundwater will influence the source area. Changes in field analytical results from the upgradient well to the source area well will be reflected in samples from monitoring wells further downgradient.

The general characteristics of the two redox environments are summarized in the following table.

Aerobic/Oxidizing	Anaerobic/Reducing
• Measurable dissolved oxygen (>1 to 2 ppm)	• No measurable dissolved oxygen (<1 ppm)
• Measurable nitrate	• No measurable nitrate
• No measurable dissolved manganese	• Measurable dissolved manganese
• No measurable dissolved ferrous iron	• Measurable dissolved ferrous iron
• Measurable dissolved sulfate	• No measurable dissolved sulfate
• No measurable dissolved sulfide	• Measurable dissolved sulfide
• No measurable dissolved methane	• Measurable dissolved methane
• No measurable dissolved hydrogen	• Measurable dissolved hydrogen

Transitional environments between these two extremes may have intermediate characteristics and are actually quite common. Because reactions are mediated by biological systems, equilibrium (the basis for the figure in Attachment B) conditions within the aquifer should not be expected. For example, sulfate reduction environments may occur in close proximity to methanogenic environments, and this natural attenuation data may be difficult to interpret. Carefully collected and analyzed field measurements and sample collections for fixed-base laboratory analyses are designed to characterize the aquifer environment along the continuum between strongly aerobic and strongly anaerobic. Because the land surface environment is generally more oxidizing than any groundwater environment, sample handling at the point of collection and analysis is extremely important in preserving the chemical integrity of the groundwater sample.

6.0 REFERENCES

American Society for Testing and Materials (ASTM), 1998. Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites, Designation: E1943-98, West Conshohocken, Pennsylvania.

Chemetrics, 2002, http://www.chemetrics.com.

Department of the Navy, 1998. Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Department of the Navy, September. Prepared by T. H. Weidemeier and F. H. Chappelle.

USEPA (United States Environmental Protection Agency), 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, Office of Research and Development, Washington, D.C.

Hach Company, 1999. DR-890 Colorimeter Procedures Manual, Product Number 48470-22, Loveland Colorado.

Hach Company, 1999. Digital Titrator (manual), Model Number 16900, Catalog Number 16900-08. Loveland, Colorado.

Hach Company, 2002, http://www.hach.com/.

USEPA, 1997. Draft EPA Region 4 Suggested Practices for Evaluation of a Site for Natural Attenuation (Biological Degradation) of Chlorinated Solvents; Version 3.0. November.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA OSWER Directive 9200.4-17P, April 21, 1999

ATTACHMENT A

HYPOTHETICAL LONG-TERM MONITORING STRATEGY

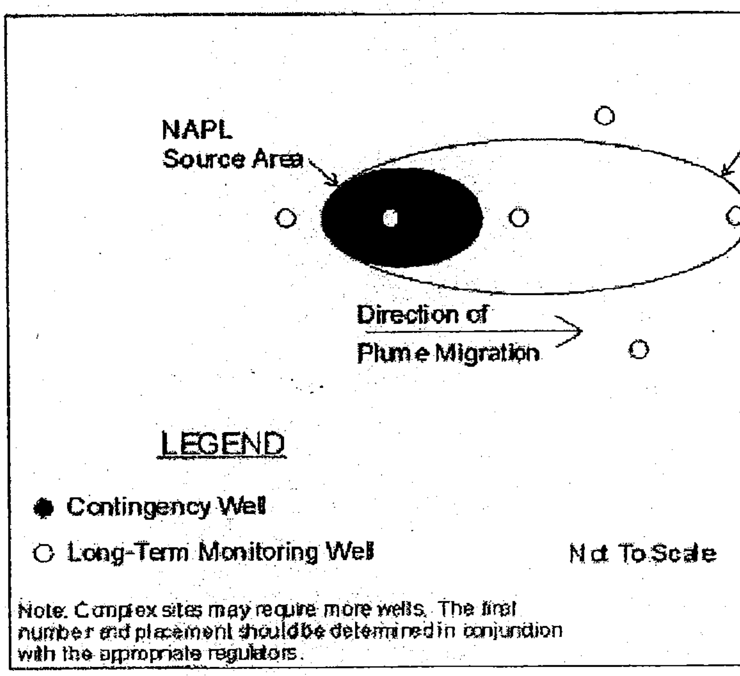

Figure 6.1
Hypothetical Long-Term Monitoring Strategy - Non-Discharging Plume

Taken from: Department of the Navy, 1998, Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Prepared by Todd Weidemeier and Francis Chappelle.

ATTACHMENT B

REDOX POTENTIALS FOR VARIOUS ELECTRON ACCEPTORS

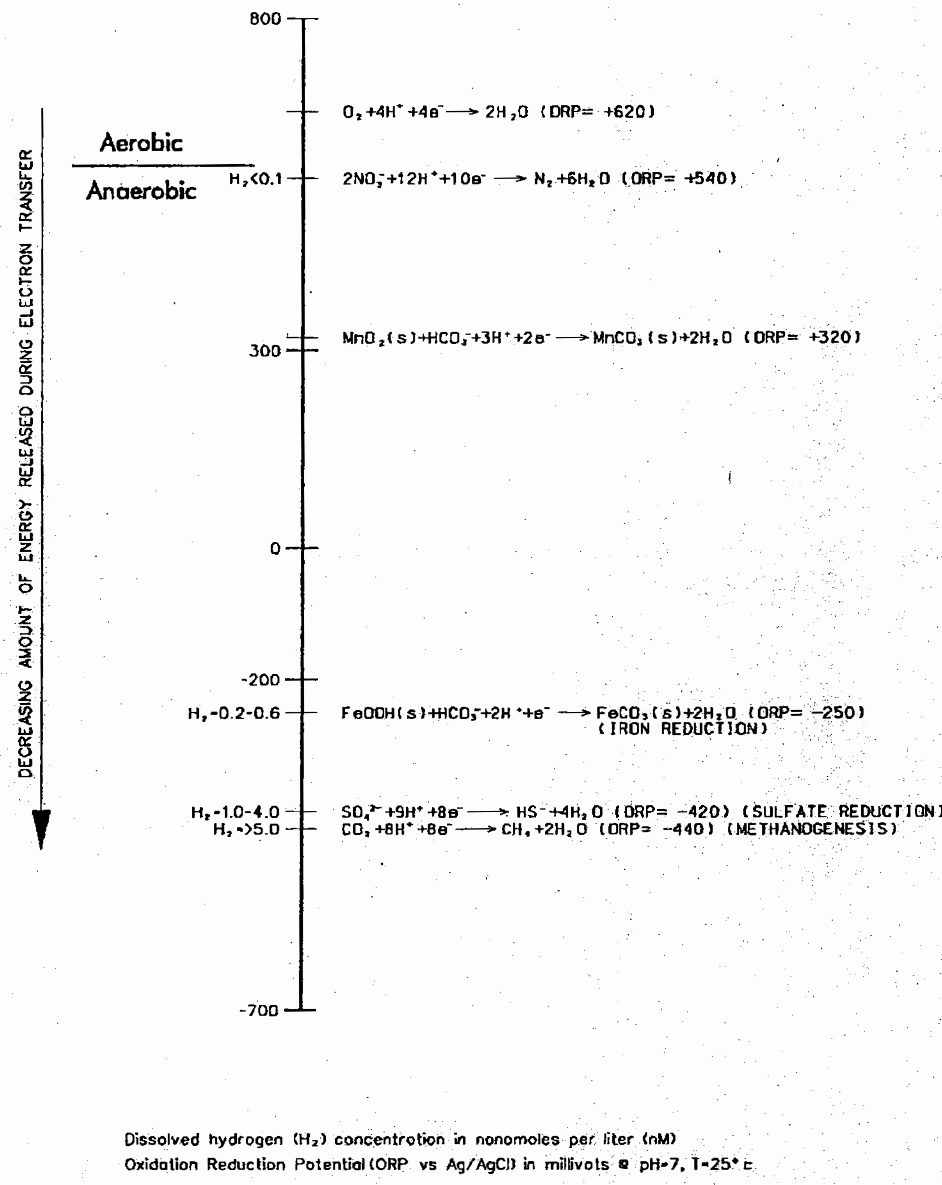

FIGURE B
REDOX POTENTIALS
FOR VARIOUS ELECTRON ACCEPTORS

k:\dgn\navy\orlando\sites\sa2\sa2-033.dgn 9-19-02

ATTACHMENT C

NATURAL ATTENUATION PARAMETERS FOR CHLORINATED VOLATILE ORGANIC COMPOUND PLUMES SCREENING PROCESS SUMMARY FOR REDUCTIVE (ANAEROBIC) DECHLORINATION

Potential Electron Donors	Electron Acceptors:		Reduced Species:		Related Dechlorination Pathway:
	Dissolved Oxygen	⇒	Carbon Dioxide (CO_2)	~	DCE → VC → CO_2
Native total organic carbon (TOC)	Manganese (Mn^{4+})	⇒	Manganese (Mn^{2+})	~	DCE → VC
Anthropogenic carbon (e.g., leachate)	Nitrate (NO_3)	⇒	Nitrite (NO_2)	~	DCE → VC
Fuel hydrocarbons (e.g., BTEX)	Ferric Iron (Fe^{3+})	⇒	Ferrous Iron (Fe^{2+})	~	DCE → VC → CO_2
Lightly chlorinated solvents (DCE/VC)	Sulfate (SO_4)	⇒	Sulfide (S^{2-}, HS^-, H_2S)	~	TCE → DCE → VC → Ethene
	Carbon Dioxide (CO_2)	⇒	Methane (CH_4)	~	PCE → TCE → DCE → VC → Ethene

Geochemical Parameter List:

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (e.g., benzene, toluene, ethylbenzene, and xylene; BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe^{2+})	F	Product of iron reduction	1
Sulfate [and sulfide (S^{-2})]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H_2S)	F	Common product of sulfate reduction	1
Methane, ethane, ethene	L	Product of methanogenesis; daughter products of reductive dechlorination	1
Chloride	L	Ultimate daughter product of reductive dechlorination	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance, temperature, turbidity	F	General water quality determination	1
Carbon dioxide (CO_2)	F	Anaerobic electron acceptor (methanogenesis); biotic respiration indicator	2
Alkalinity/DIC	F	Buffering capacity; biotic respiration indicator	2
Hydrogen, dissolved	L	Fingerprint for characterizing electron acceptor pathway - indicator of what redox is occurring	2
TOC - upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Volatile fatty acids	L	Determination of anthropogenic carbon used as an electron donor	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).
See Attachment E for details regarding analytical methods.

ATTACHMENT D

NATURAL ATTENUATION PARAMETERS FOR PETROLEUM HYDROCARBON PLUMES SCREENING PROCESS SUMMARY FOR OXIDATIVE (AEROBIC) DEGRADATION

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (and product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe^{2+})	F	Product of iron reduction	1
Sulfate [and Sulfide (S^{-2})]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H_2S)	F	Common product of sulfate reduction	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance temperature, turbidity	F	General water quality determination	1
Dissolved methane (CH_4)	L	Product of methanogenesis	1
Anions: chloride (Cl), nitrate (NO_3), nitrite (NO_2), phosphate (PO_4), sulfate (SO_4)	L		1
TOC - Upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Biological oxygen demand (BOD)	L	Understanding of aquifer oxygen demand	3
Chemical oxygen demand (COD)	L	Understanding of aquifer oxygen demand	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).

See Attachment E for details regarding analytical methods.

ATTACHMENT E
GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUMES, CONTAINERS, PRESERVATION, HOLDING TIMES, AND DETECTION RANGES
PAGE 1 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Alkalinity	CHEMetrics K-9810, K-9815, K-9820 -ASTM D 1067-92 -EPA 310.1	Titret® Titration Ampules / Hydrochloric Acid; Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine total alkalinity. Filter if turbid (>10 NTU).	10-100 (K-9810) 50-500 (K-9815) 100-1000 (K-9820)	N/A	10 50 100-
Alkalinity	Fixed-base lab -EPA 310.1	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 14 days. Filter if turbid.	N/A	N/A	N/A
Alkalinity / Dissolved Inorganic Carbon	HACH AL-DT -HACH 8203 -SM 2320 / SM 403	Digital Titration / Hydrochloric Acid, Phenolphthalein (P) and Total (M)	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine carbonate, bicarbonate, and hydroxide ions. Filter if turbid as recommended by manufacture. May use a pH meter for colored samples.	10-4000	N/A	10
Arsenic	Fixed-base lab -SW-6010 B	N/A	1 liter glass or polyethylene container, HNO_3 to pH $\leq$ 2, 6 months.	N/A	N/A	N/A
Biochemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	2 liter HDPE. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Carbon Dioxide, dissolved	CHEMetrics K-1910, K-1920, K-1925 -ASTM D 513.82 -SM 4500-CO_2-C	Titret® Titration Ampules / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head.	10-100 (K-1910) 100-1000 (K-1920) 250-2500 (K-1925)	N/A	10 100 250
Carbon Dioxide, dissolved	Fixed-base lab - VOA water sample (Vaportech)	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Carbon Dioxide, dissolved	Fixed-base lab -Microseeps gas stripping cell	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Carbon Dioxide, dissolved	HACH CA-DT -HACH 8205 -Mod. SM 406	Digital Titration / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Do not aerate or agitate. Analyze at well head.	10-1000	N/A	10
Chemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	125 mL HDPE. H_2SO_4 to pH <2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chloride (Cl)	Fixed-base lab -EPA 300	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chlorine - Total (Cl_2)	HACH DR-850 -HACH 8167 -SM 4500-Cl	Colorimeter / DPD Method	Field. Follow test kit instructions.	0.02-2.00	$\pm$ 0.01 mg/L with a 1.00 mg/L chlorine solution.	1
Conductance, Specific	Field Meter -SW-9050 A	Direct Reading Meter	100 to 250 mL in glass or plastic container. Analyze immediately.	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 tol 3 vials by (Vaportech).	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A

ATTACHMENT E
GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES
PAGE 2 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Ethene, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethene, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Fraction Organic Carbon (foc) -Soil Upgradient Saturated Soil	Fixed-base lab -Walk-Black -SW-846 9060	N/A	200 gram glass jar. Cool to 4°C. Analyze within 14 days.	N/A	N/A	N/A
Hydrogen, dissolved	Fixed-base lab -Microseeps or Vapor Tech gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial.	N/A	N/A	N/A
Iron, ferrous (Fe^{+2})	HACH DR-850 -HACH 8146 -Mod. SM 315 B	Colorimeter 1, 10 Phenanthrolein	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-3.00	$\pm$0.017 mg/L with a 2.00 mg/L Fe^{2+} solution.	0.03
Iron, ferrous (Fe^{+2})	HACH IR-18C -Mod. SM 315 B	Color Disc 1, 10 Phenanthrolein	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-10	N/A	0.2
Iron, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Manganese (Mn^{+2})	HACH DR-850 -HACH 8034 -CFR 44(116) 34193	Colorimeter / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-20.0	$\pm$ 0.18 mg/L with a 10.00 mg/L Mn solution.	0.12
Manganese (Mn^{+2})	HACH MN-5 -Mod. SM 319 B -CFR 44(116) 34193	Color Disc / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-3	N/A	0.1
Manganese, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Nitrate (NO_3^-)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Nitrate (NO_3^-)	HACH DR-850 -HACH 8192 -Mod. EPA 353.2	Colorimeter / Cadmium Reduction	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Pretreatment required if nitrite is present.	0-0.50	$\pm$ 0.03 mg/L with a 0.25 mg/L of nitrate nitrogen (NO_3^- N) solution.	0.01
Nitrite (NO_2^-)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A

ATTACHMENT E

GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES

PAGE 3 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Nitrite (NO_2^-)	HACH DR-850 -HACH 8507 -Mod. EPA 354.1 -Mod. SM 419 -CFR 44(85) 25595	Colorimeter / Diazotization	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-0.350	± 0.001 mg/L with a 0.250 mg/L nitrite nitrogen solution.	0.005
Nitrogen, dissolved	Fixed-base lab -Microseeps gas stripping cell - Vaportech VOA water sample	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required for Microseeps. Ship in glass septum vial (Microseeps) or VOA vial (Vaportech).	N/A	N/A	N/A
Nitrogen, Total Kjeldahl	Fixed-base lab -EPA 351.2	N/A	500 mL plastic/glass container. Cool to 4°C. H_2SO_4 to pH ≤ 2. Analyze within 28 days.	N/A	N/A	N/A
Oxidation Reduction Potential	Field Meter - ASTM D-1498	Direct Reading Meter	Field. Do not aerate. Gently agitate probe using flow over ot flow-through method. Analyze immediately at well head.	N/A	N/A	N/A
Oxygen, dissolved	CHEMetrics K-7501, K-7512 -ASTM D 5543-94 -ASTM D 887-92	CHEMets® Vacuum Vials / Rhodazine D and Indigo Carmine	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 (K-7501) 1-12 (K-7512)	N/A	0.025 1
Oxygen, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Oxygen, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Oxygen, dissolved	HACH OX-DT -HACH 8215 -SM 4500-O-G	Digital Titration / Azide Modification of Winkler Digital Titration Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	1-10	N/A	1
Oxygen, dissolved	HACH DR-850 (AccuVac Ampules) LR HRDO Method	-Indigo Carmine Method -Rhadazine D Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-0.8 ppm 0-10 ppm	0.01 ppm 0.1 ppm	N/A
Oxygen, dissolved	Field Meter	Direct Reading Meter	Analyze immediately at well head. Avoid agitation and analyze immediately at well head. Used for well stabilization measurement parameter only.	N/A	N/A	N/A
pH	Field Meter -SW 9040B	Direct Reading Meter	Analyze immediately at well head.	N/A	N/A	N/A
Phosphate (ortho)	Fixed-base lab -EPA 300	Ion Chromatography	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Phosphate, potassium	Fixed-base lab -SW-846 6010B	Inductively Coupled Plasma	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Salinity	Field Meter	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A
Sulfate (SO_4^{-2})	Fixed-base lab	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Sulfate (SO_4^{-2})	HACH DR-850 -HACH 8051 -EPA 375.4	Colorimeter / Turbimetric SulfaVer 4	Field. Follow test kit instructions. Filter if turbid as recommended by the manufacture.	0-70	± 0.5 mg/L with a 50 mg/L sulfate solution.	4.9
Sulfide (Hydrogen Sulfide, H_2S)	HACH HS-C -HACH Proprietary -Mod. SM 426 C	Color Chart / Effervescence of H_2S through sulfide reactive paper.	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-5	N/A	0.1
Sulfide (S^{-2})	CHEMetrics K-9510 -SM 4500-S^2	CHEMets® Vacuum Vials / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 1-10	N/A	0.1 1

ATTACHMENT E

GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER, PRESERVATION, HOLDING TIME, AND DETECTION RANGES
PAGE 4 OF 4

Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Sulfide (S^{-2})	Fixed-base lab -EPA 376.1/376.2	N/A	1 liter in plastic container, no headspace. NaOH to pH >9. Cool to 4°C. Avoid agitation and analyze within 7 days.	N/A	N/A	N/A
Sulfide (S^{-2})	HACH DR-850 -HACH 8131 -SM 4500-S^{2}	Colorimeter / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-0.70	± 0.02 mg/L with a 0.73 mg/L sulfide solution.	0.01
Sulfide (S^{-2})	HACH HS-WR -SM 4500-S^{2}	Color Disc / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-11.25	N/A	0.1-2.5
Temperature	Field Meter / Thermometer - E170.1	Direct Reading Meter / Thermometer	Analyze immediately.	N/A	N/A	N/A
Total Organic Carbon (TOC)-Groundwater	Fixed-base lab -E 415.1	N/A	125 mL HDPE. H_2SO_4 to pH < 2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Turbidity	Field Meter - E 180.1	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A

N/A = Not applicable.

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 1 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

FIELD ANALYTICAL LOG SHEET GEOCHEMICAL PARAMETERS

Tetra Tech NUS, Inc.

Page __ of __

Project Site Name: ____________________ Sample ID No.: ____________________

Project No.: ____________________ Sample Location: ____________________

Sampled By: ____________________ Duplicate: ☐

Field Analyst: ____________________ Blank: ☐

Field Form Checked as per QA/QC Checklist (initials): ______

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	ORP (Eh)
Time:	(Visual)	(S.U.)	(mS/cm)	(°C)	(NTU)	(mg/l)	(%)	(+/- mv)
Method:								

SAMPLE COLLECTION/ANALYSIS INFORMATION:

ORP (Eh) (+/- mv)

Electrode Make & Model: ____________________

Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen

Dissolved Oxygen:

Equipment: Chemetrics Test Kit

Concentration: __________ ppm

Range Used:	Range	Method	Concentration ppm
☐	0 to 1 ppm	K-7510	
☐	1 to 12 ppm	K-7512	

Analysis Time: __________

Equipment: HACH Digital Titrator OX-DT

Analysis Time: __________

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier		Concentration
______	x 0.01	=	mg/L
______	x 0.02	=	mg/L

Notes:

Carbon Dioxide:

Equipment: Chemetrics Test Kit

Concentration: __________ ppm

Range Used:	Range	Method	Concentration ppm
☐	10 to 100 ppm	K-1910	
☐	100 to 1000 ppm	K-1920	
☐	250 to 2500 ppm	K-1925	

Analysis Time: __________

Equipment: HACH Digital Titrator CA-DT

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count			Concentration
______	x 0.1	=	mg/L
______	x 0.2	=	mg/L
______	x 1.0	=	mg/L
______	x 2.0	=	mg/L

Standard Additions: ☐ Titrant Molarity: ________ Digits Required: 1st.: ______ 2nd.: ______ 3rd.: ______

Notes:

Hydrogen, dissolved

Equipment: Bubble strip sampling field method

Start stripper at __________ (time)

End stripper at __________ (time)

Total stripper time __________

Pump rate __________ milliliters/minute

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 2 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: ____________ Sample ID No.: ____________
Project No.: ____________ Sample Location: ____________
Sampled By: ____________ Duplicate: ☐
Field Analyst: ____________ Blank: ☐

Alkalinity:

Equipment: Chemetrics Test Kit Concentration: ________ ppm

Range Used:	Range	Method	Concentration ppm
☐	10 to 100 ppm	K-9810	
☐	50 to 500 ppm	K-9815	
☐	100 to 1000 ppm	K-9820	

Analysis Time: ________

Filtered: ☐

Equipment: HACH Digital Titrator AL-DT

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	____ & ____	x 0.1	= mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	____ & ____	x 0.4	= mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	____ & ____	x 1.0	= mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	____ & ____	x 2.0	= mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	____ & ____	x 5.0	= mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	____ & ____	x 10.0	= mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

Standard Additions: ☐ Titrant Molarity: ________ Digits Required: 1st.: ______ 2nd.: ______ 3rd.: ______

Notes:

Ferrous Iron (Fe^{2+}):

Equipment: DR-850 DR-8__ Range: 0 - 3.00 mg/L Concentration: ________ ppm

Program/Module: 500nm 33

Analysis Time: ________

Equipment: IR-18C Color Wheel Range: 0 - 10 mg/L

Notes: Filtered: ☐

Hydrogen Sulfide (H_2S): Range: 0 - 5 mg/L

Equipment: HS-C Other: ____________ Concentration: ________ ppm

Exceeded 5.0 mg/L range on color chart ☐ Analysis Time: ________

Notes:

Sulfide (S^{2-}):

Equipment: Chemetrics Test Kit Range: 0 - 10 mg/L Concentration: ________ ppm

Range Used:	Range	Method	Concentration ppm
☐	0 to 1 ppm	K-9510	
☐	1 to 10 ppm	K-9510	

Analysis Time: ________

Filtered: ☐

Equipment: DR-850 DR-8__ Range: 0 - 0.70 mg/L

Program/Module: 610nm 93

Notes:

ATTACHMENT F

FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS PAGE 3 OF 3

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET GEOCHEMICAL PARAMETERS

Page __ of __

Project Site Name: ____________ Sample ID No.: ____________
Project No.: ____________ Sample Location: ____________
Sampled By: ____________ Duplicate: ☐
Field Analyst: ____________ Blank: ☐

Sulfate (SO_4^{2}):

Equipment DR-850 DR-8__ Range: 0 - 70 mg/L Concentration: ________ ppm
Program/Module: ________ 91 Analysis Time: ________
Standard Solution: ☐ Results: ________ Filtered: ☐
Standard Additions: ☐ Digits Required: 0.1ml: ______ 0.2ml: ______ 0.3ml: ______
Notes:

Nitrate (NO_3^--N):

Equipment DR-850 DR-8__ Range: 0 - 0.50 mg/L(1) Concentration: ________ ppm
Program/Module: 55 Analysis Time: ________ Filtered: ☐
Standard Solution: ☐ Results: ________ Nitrite Interference Treatment: ☐ Reagent Blank Correction: ☐
Standard Additions: ☐ Digits Required: 0.1ml: ______ 0.2ml: ______ 0.3ml: ______
Alternate forms: NO_3 ______ $NaNO_2$ ________ mg/L

Notes (1): If results are over limit use dilution method at step 3, 5ml sample 10ml DI result X3, range upto 1.5mg/L

Notes:

Nitrite (NO_2^--N):

Concentration: ________ ppm
Equipment DR-850 DR-8__ Range: 0 - 0.350 mg/L Analysis Time: ________ Filtered: ☐
Program/Module: 62
Standard Solution: ☐ Results: ________ Reagent Blank Correction: ☐
Notes:

Manganese (Mn^{2+}):

Concentration: ________ ppm
Equipment DR-850 DR-8__ Range: 0 - 20.0 mg/L Analysis Time: ________ Filtered: ☐
Program/Module: 525nm 41
Standard Solution: ☐ Results: ________ Digestion: ☐ Reagent Blank Correction: ☐
Standard Additions: ☐ Digits Required: 0.1ml: ______ 0.2ml: ______ 0.3ml: ______

Equipment HACH MN-5 Range: 0 - 3 mg/L
Notes:

QA/QC Checklist:

All data fields have been completed as necessary: ☐
Correct measurement units are cited in the SAMPLING DATA block: ☐
Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: ☐
Mulitplication is correct for each *Multiplier* table: ☐
Final calulated concentration is within the appropriat *Range Used* block: ☐
Alkalinity *Relationship* is determined appropriatly as per manufacturer (HACH) instructions: ☐
QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐
Nitrite interference treatment was used for Nitrate test if Nitrite was detected: ☐
Title block on each page of form is initialized by person who performed this QA/QC Checklist: ☐

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-6.3	Page 1 of 12
		Effective Date 09/03	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject FIELD DOCUMENTATION		Approved D. Senovich DJ.	

TABLE OF CONTENTS

SECTION **PAGE**

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 Field Notebooks

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is colleted, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS

Groundwater Sample Log Sheet
Surface Water Sample Log Sheet
Soil/Sediment Sample Log Sheet
Container Sample and Inspection Sheet
Geochemical Parameters (Natural Attenuation)
Groundwater Level Measurement Sheet
Pumping Test Data Sheet
Packer Test Report Form
Boring Log
Monitoring Well Construction Bedrock Flush Mount
Monitoring Well Construction Bedrock Open Hole
Monitoring Well Construction Bedrock Stick Up
Monitoring Well Construction Confining Layer
Monitoring Well Construction Overburden Flush Mount
Monitoring Well Construction Overburden Stick Up
Test Pit Log
Monitoring Well Materials Certificate of Conformance
Monitoring Well Development Record

Daily Activities Record
Field Task Modification Request
Hydraulic Conductivity Test Data Sheet
Low Flow Purge Data Sheet
QA Sample Log Sheet
Equipment Calibration Log
Field Project Daily Activities Checklist
Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ____________________ DATE: ____________________

SITE LEADER: ____________________
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
________	________	________
________	________	________
________	________	________

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ______.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _______.
4. Well ______ drilled. Rig geologist was __________________. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _________.
8. Test pit _______ dug with cuttings placed in dump truck. Rig geologist was _______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

____

Field Operations Leader

ATTACHMENT B

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**	
Sample No:		**Matrix:**
Date:	**Time:**	**Preserve:**
Analysis:		
Sampled by:		**Laboratory:**

ATTACHMENT C

TETRA TECH NUS, INC. — CHAIN OF CUSTODY — NUMBER 3413 — PAGE ____ OF ______

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS									COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME
COMMENTS					

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date ________________	**Date** ________________
Signature ________________	**Signature** ________________

TABLE OF CONTENTS

1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The objective/purpose of this SOP is intended to protect site personnel, general public, and the sample integrity through the prevention of cross contamination onto unaffected persons or areas. It is further intended through this procedure to provide guidelines regarding the appropriate procedures to be followed when decontaminating drilling equipment, monitoring well materials, chemical sampling equipment and field analytical equipment.

2.0 SCOPE

This procedure applies to all equipment including drilling equipment, heavy equipment, monitoring well materials, as well as chemical sampling and field analytical equipment decontamination that may be used to provide access/acquire environmental samples. Where technologically and economically feasible, single use sealed disposable equipment will be employed to minimize the potential for cross contamination. This procedure also provides general reference information on the control of contaminated materials.

3.0 GLOSSARY

Acid - For decontamination of equipment when sampling for trace levels of inorganics, a 10% solution of nitric acid in deionized water should be used. Due to the leaching ability of nitric acid, it should not be used on stainless steel.

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - Is a solution selected/identified within the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Deionized water is tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet CAP and NCCLS specifications for reagent grade, Type I water.

Potable Water - Tap water used from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Employs high pressure pumps and nozzle configuration to create a high pressure spray of potable water. High pressure spray is employed to remove solids.

Solvent - The solvent of choice is pesticide-grade Isopropanol. Use of other solvents (methanol, acetone, pesticide-grade hexane, or petroleum ether) may be required for particular projects or for a particular purpose (e.g. for the removal of concentrated waste) and must be justified in the project planning documents. As an example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - This method employs a high pressure spray of heated potable water. This method through the application of heat provides for the removal of various organic/inorganic compounds.

4.0 RESPONSIBILITIES

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved Standards Operating Procedures or as otherwise dictated by the approved project plan(s).

Site Health and Safety Officer (SHSO) - The SHSO exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on-site (as part of the equipment inspection), leaving the site, moving between locations are required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Failure to meet these objectives are sufficient to restrict equipment from entering the site/exiting the site/ or moving to a new location on the site until the objectives are successfully completed.

5.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or the isolation of contaminants. In order to accomplish this activity a level of preparation is required. This includes site preparation, equipment selection, and evaluation of the process. Site contaminant types, concentrations, media types, are primary drivers in the selection of the types of decontamination as well as where it will be conducted. For purposes of this SOP discussion will be provided concerning general environmental investigation procedures.

The decontamination processes are typically employed at:

- Temporary Decontamination Pads/Facilities
- Sample Locations
- Centralized Decontamination Pad/Facilities
- Combination of some or all of the above

The following discussion represents recommended site preparation in support of the decontamination process.

5.1 <u>Decontamination Design/Constructions Considerations</u>

5.1.1 Temporary Decontamination Pads

Temporary decontamination pads are constructed at satellite locations in support of temporary work sites. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soils generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations

- Site Location – The site selected should be within a reasonable distance from the work site but should avoid:

  - Pedestrian/Vehicle thoroughfares
  - Areas where control/custody cannot be maintained
  - Areas where a potential releases may be compounded through access to storm water transport systems, streams or other potentially sensitive areas.
  - Areas potentially contaminated.

- Pad – The pad should be constructed to provide the following characteristics

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination.

  - Slope – An adequate slope will be constructed to permit the collection of the water and potentially contaminated soils within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks.

  - Sidewalls – The sidewalls should be a minimum of 6-inches in height to provide adequate containment for wash waters and soils. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls maybe constructed of wood, inflatables, sand bags, etc. to permit containment.

  - Liner – Depending on the types of equipment and the decontamination method the liner should be of sufficient thickness to provide a puncture resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. Achieving the desired thickness maybe achieved through layering lighter constructed materials. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner a light coating of sand maybe applied to provide traction as necessary.

  - Wash/drying Racks – Auger flights, drill/drive rods require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process. A minimum ground clearance of 2-feet is recommended.

  - Maintenance – The work area should be periodically cleared of standing water, soils, and debris. This action will aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross contamination. Hoses should be gathered when not in use to eliminate potential tripping hazards.

5.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and direct push activities decontamination of drive rods, Macro Core Samplers, split spoons, etc. are typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected media. Drying racks will be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/re-use.

5.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations sampling devices such as trowels, pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition.

5.2 <u>Equipment Decontamination Procedures</u>

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

5.2.1 Monitoring Well Sampling Equipment

5.2.1.1 <u>Groundwater sampling pumps – This includes pumps inserted into the monitoring well such as Bladder pumps, Whale pumps, Redi-Flo, reusable bailers, etc.</u>

1) Evacuate to the extent possible, any purge water within the pump.

2) Scrub using soap and water and/or steam clean the outside of the pump and tubing, where applicable.

3) Insert the pump and tubing into a clean container of soapy water. Pump a sufficient amount of soapy water through the pump to flush any residual purge water. Once flushed, circulate soapy water through the pump to ensure the internal components are thoroughly flushed.

4) Remove the pump and tubing from the container, rinse external components using tap water. Insert the pump and tubing into a clean container of tap water. Pump a sufficient amount of tap water through the pump to evacuate all of the soapy water (until clear).

5) Rinse equipment with pesticide grade isopropanol

6) Repeat item #4 using deionized water through the hose to flush out the tap water and solvent residue as applicable*.

7) Drain residual deionized water to the extent possible, allow components to air dry.

8) Wrap pump in aluminum foil or a clear clean plastic bag for storage.

5.2.1.2 <u>Electronic Water Level Indicators/Sounders/Tapes</u>

During water level measurements, rinsing with the extracted tape and probe with deionized water and wiping the surface of the extracted tape is acceptable. However, periodic full decontamination should be conducted as indicated below.

* - The solvent should be employed when samples contain oil, grease, PAHs, PCBs, and other hard to remove materials. If these are not of primary concern, the solvent step may be omitted. In addition, do not rinse PE, PVC, and associated tubing with solvents.

1) Wash with soap and water
2) Rinse with tap water
3) Rinse with deionized water

Note: In situations where oil, grease, free product, other hard to remove materials are encountered probes and exposed tapes should be washed in hot soapy water.

5.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) should be cleaned per manufacturer's instructions. This generally includes wiping down the sensor housing and rinsing with tap and deionized water.

Coolers/Shipping Containers employed to ship samples are received from the lab in a variety of conditions from marginal to extremely poor. Coolers should be evaluated prior to use for

- Structural integrity – Coolers missing handles or having breaks within the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples will not be attempted and request a replacement unit.

- Cleanliness – As per protocol only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or associated with noticeable odors it should be decontaminated prior to use.

  1) Wash with soap and water
  2) Rinse with tap water
  3) Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and notify the laboratory to provide a replacement unit.

5.2.2 Down-Hole Drilling Equipment

This includes any portion of the drill rig that is over the borehole including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. This procedure is to be employed prior to initiating the drilling/sampling activity, then between locations.

1) Remove all soils to the extent possible using shovels, scrapers, etc. to remove loose soils.
2) Through a combination of scrubbing using soap and water and/or steam cleaning remove visible dirt/soils.
3) Rinse with tap water.
4) Rinse equipment with pesticide grade isopropanol
5) To the extent possible allow components to air dry.
6) Wrap or cover equipment in clear plastic until it is time to be used.

5.2.3 Soil/Sediment Sampling Equipment

This consists of soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1) Remove all soils to the extent possible.

2) Through a combination of scrubbing using soap and water and/or steam cleaning remove visible dirt/soils.

3) Rinse with tap water.

4) Rinse equipment with pesticide grade isopropanol

5) Rinse with deionized water

6) To the extent possible allow components to air dry.

7) If the device is to be used immediately, screen with a PID/FID to insure all solvents (if they were used) and trace contaminants have been adequately removed.

8) Once these devices have been dried wrap in aluminum foil for storage until it is time to be used.

5.3 Contact Waste/Materials

During the course of field investigations disposable/single use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.) broken sample containers.

With the exception of the broken glass, single use articles should be cleaned (washed and rinsed) of visible materials and disposed of as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned should be containerized for disposal in accordance with applicable federal state and local regulations.

5.3.1 Decontamination Solutions

All waste decontamination solutions and rinses must be assumed to contain the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. The waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility. These containers must be appropriately labeled.

5.4 Decontamination Evaluation

Determining the effectiveness of the decontamination process will be accomplished in the following manner

- Visual Evaluation – A visual evaluation will be conducted to insure the removal of particulate matter. This will be done to insure that the washing/rinsing process is working as intended.

- Instrument Screening – A PID and/or an FID should be used to evaluate the presence of the contaminants or solvents used in the cleaning process. The air intake of the instrument should be passed over the article to be evaluated. A positive detection requires a repeat the decontamination process. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instruments capabilities.

- Rinsate Blanks – It is recommended that Rinsate samples be collected to

  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.

  - Single use disposable equipment – The number of samples should represent different types of equipment as well as different Lot Numbers of single use articles.

The collection and the frequency of collection of rinsate samples are as follows:

- Per decontamination method
- Per disposable article/Batch number of disposable articles

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and in an effort to avoid using a contaminated batch of single use articles. It is recommended that a follow up sample be collected during the execution of the project to insure those conditions do not change. Lastly, rinsate samples collection may be driven by types of and/or contaminant levels. Hard to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

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		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject GROUNDWATER MONITORING WELL INSTALLATION		Approved D. Senovich	

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1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium-to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 <u>Well Development Methods</u>

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject WELL ABANDONMENT		Approved D. Senovich	

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1.0 PURPOSE

Well abandonment is that procedure by which any monitoring well is permanently closed. Abandonment procedures are designed to prevent fluids from entering or migrating within the monitoring well. Therefore, an abandoned monitoring well must be sealed in such a manner that it can not act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers.

It is important that the appropriate state or local agency be notified of monitoring well abandonment. The application of and adherence to this SOP must be tailored to applicable state, local, and Federal regulatory requirements.

2.0 SCOPE

The methods described in this procedure shall be used for all projects requiring well abandonment where specific state, local, or Federal regulations are unavailable. An abandoned well shall be filled and sealed so that it will not act as a pathway for the interchange of water between the surface and subsurface or present a hazard to the environment.

3.0 GLOSSARY

Well - Any constructed access point to an aquifer, confined or unconfined, including, but not limited to, test borings, hydropunch holes, monitoring points, and production wells.

Abandon - To permanently discontinue the use of a well. Any well shall require abandonment when it is no longer serving as a monitoring point or is in such a state of disrepair that continued use for the purpose of obtaining groundwater is impracticable, or when it has been permanently disconnected from any water supply system or irrigation system.

4.0 RESPONSIBILITIES

Project Manager - It shall be the responsibility of the Project Manager and/or Project Hydrogeologist to determine the applicability of well abandonment, based on the established scope and objective of the project and program-specific requirements. It shall be the responsibility of the Project Manager (or designee) to ensure that the procedures established for well abandonment are thoroughly specified and/or referenced in the relevant project planning documents. It shall be the responsibility of the Project Manager to ensure that the Field Operations Leader is familiar with the proper procedures for well abandonment and confirm the supervising project geologist or the subcontractor performing the well abandonment are qualified to perform such activities.

Field Operations Leader (FOL) - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians and/or drilling personnel are thoroughly familiar with this Standard Operating Procedure. It shall be the responsibility of the FOL to ensure that the procedures identified in this SOP are used during well abandonment.

5.0 PROCEDURES

5.1 General

Well abandonment is warranted when the project team has reason to believe, on the basis of local conditions, that the well is causing or is a potential source of pollution to an aquifer; is a production well that is producing water that is polluted; or does not have a certificate of potability, if required. Wells may also be abandoned once their designed purposes have been fulfilled and are determined to no longer be of use.

Well abandonment is conducted to eliminate physical hazards, prevent groundwater contamination, prevent intermixing of aquifer waters, and conserve aquifer yield and hydrostatic head.

Please note Federal, state, and local regulations concerning this activity may vary. Therefore, applicable regulatory requirements should be reviewed to determine the need for Licensed/Certified Well Drillers to complete/oversight this activity.

5.2 <u>Material for Sealing</u>

Acceptable sealing materials include concrete, portland cement grout, sodium-base bentonite clay, or combinations of these materials. These materials are defined as follows:

- Concrete may be used for filling the upper part of a well or water bearing formation, or plugging short sections of casing and filling large diameter wells.
- Portland cement grout is superior for sealing small openings, penetrating any annular space outside the casing, and for filling voids in the surrounding formation. Portland cement grout shall be composed of one bag of Type I cement per 6 to 8 gallons of water. Two parts sand to one part cement may be added.
- Bentonite clay, when applied as a heavy mud-laden fluid under pressure, has most of the advantages of cement grout, but under some conditions may be carried away into the surrounding formation. A bentonite clay mixture shall be composed of not less than 2 pounds of clay per gallon of water. Bentonite clay may not be used where it will come in contact with water of a pH below 5.0 or total dissolved solids (TDS) content greater than 1,000 mg/L or both. Bentonite may also be added to cement grout to add flexibility.

Fill materials include clay, silt, sand, gravel, crushed stone, or a mixtures of these materials may be used as a filler in sealing a well when used in conjunction with the sealing materials described above. Organic material may not be used and fill material may be required to be disinfected or certified clean prior to use. Spent drilling muds or drill cuttings are not to be used to seal a well.

5.3 <u>Procedures for Sealing Wells</u>

5.3.1 Preliminary Considerations

Several factors should be considered to determine the appropriate well abandonment method. These factors include:

- Conditions of the well.
- Details of well construction, including casing material, diameter of casing, depth of well, and well plumbness.
- Obstructions within the well that may interfere with filling or sealing.
- Hydrogeologic setting.
- Level of contamination and the zone or zones where it occurs.
- Regulatory requirements.

Degraded wells may not permit casing removal by pulling. Also, the casing material may dictate whether a casing can be removed intact. Stainless steel will have a higher tensile strength than PVC and may hold together while pulling the casing; PVC well casing may break under pulling and may need to be overdrilled to remove it. The depth of the well and well plumbness may limit casing removal depending on whether a casing is pulled or overdrilled. In some cases, casings can be left in-place if they are properly filled with appropriate backfill.

The formation lithology influences the selection of casing removal. Unconsolidated materials can be drilled with hollow-stem augering techniques whereas consolidated materials cannot. Unconsolidated materials may also cave-in during well casing removal.

5.3.2 Filling and Sealing Procedures

Drilled wells (all wells not dug) shall be filled with sealing material or a combination of sealing material and fill material.

In some cases, well casing removal is necessary for well abandonment. If the borehole is unstable and may cave-in, sealing material will be emplaced simultaneously during casing removal. If the well is not grouted, casing may be pulled with hydraulic jacks or a drilling rig. It may also be pulled by sandlocking. Sandlocking consists of lowering a pipe wrapped with burlap approximately 2/3 of the well depth and filling the burlap wrap with sand. The pipe is slowly lifted and locks the sand, pulling the casing. Well casings can also be removed by overdrilling. Wells can be overdrilled with larger diameter hollow steam or solid stem augers or direct rotary techniques, using air or mud. Augers used for overdrilling should be at least 2 inches larger in diameter than the diameter of the well casing.

If well casing is in poor condition or is grouted in place, the casing may be ripped or perforated and filled and pressure grouted in place.

Abandoned wells shall be filled with the appropriate filling and sealing material placed from the bottom of the well upward. When Portland cement grout or concrete is used, it shall be placed in continuous operation using a tremie pipe. Sealing material shall be placed in the interval or intervals to be sealed by methods that prevent free fall, dilution, and/or separation of aggregates from cementing material.

A well constructed in unconsolidated material in an unconfined groundwater zone shall be filled and sealed by placing fill material in the well to the level of the water table, and filling the remainder of the well with sealing material. If the water table is at a depth greater than 40 feet, a minimum of 40 feet of sealing material shall be required.

A well which penetrates several aquifers or formations shall be filled and sealed in such a way as to prevent the vertical movement of water from one aquifer or formation to another. If the casing has been removed, sealing material shall be placed opposite the confining formations and from the surface down to the first confining formation. Sand and other suitable fill material may be placed opposite the producing aquifer. Ideally, the entire well can be filled with sealing material. If the casing has not been removed, the entire well shall be fill with sealing material.

A well penetrating creviced or cavernous rock shall be filled using coarse fill material opposite the cavernous or creviced rock portions of the well. Sealing material shall extend from the top of the unfractured rock portion of the well or base of the casing, whichever is deeper, to the surface. The minimum depth of sealing material may not be less than 10 feet.

In the case where wells penetrate specific aquifers where conditions necessitate the sealing of specific aquifers or formations, the annular space in the area of the specific aquifer or formation shall be sealed during the abandonment of the well.

A dug well exceeding 24 inches in diameter shall be filled and sealed by placing fill material (excluding clay or silt) in the well to a level approximately 5 feet below the land surface, and placing a 3 foot plug of sealing material above the fill. The remainder of the well shall be back filled with soil material.

6.0 REFERENCES

Maryland Department of the Environment (MDE Regulations); Title 26, Subtitle 04; Regulation of Water Supply, Sewage Disposal, and Solid Waste; Chapter 4--Well Construction.

U.S. EPA, February 1990. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design, remedial alternative design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.
- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.
- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.
- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotosonic
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.

- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.

- In-situ samples cannot be taken, unless the hole is cased.

- Casing must generally be used in unconsolidated materials.

- Air-rotary drill rigs are large and heavy.

- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.

- Relatively quick and inexpensive.

- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.

- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).
- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

5.2.4 Rotosonic Drilling

The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.

The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.

Advantages of this method include:

- Sampling and well installation are faster as compared to other drilling methods.
- Continuous sampling, with larger sample volume as compared to split-spoon sampling.
- The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.
- Reduction of IDW by an average of 70 to 80 percent.
- Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.

Disadvantages include:

- The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.
- Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.
- There are a limited number of Rotosonic drilling contractors at the present time.

5.2.5 Reverse Circulation Rotary Drilling

The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.

Advantages of the latter method include:

- The formation water is not contaminated by the drilling water.
- Formation samples can be obtained, from known depths.
- When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.
- Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.

Disadvantages include:

- Double-wall, reverse-circulation drill rigs are rare and expensive to operate.
- Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.

5.2.6 Drill-through Casing Driver

The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.

The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:

- Split-barrel (split-spoon) sampling can be conducted while drilling.
- Well installation is easily accomplished.
- Drill rigs used are relatively small and mobile.
- The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.

Some of the disadvantages include:

- This method can only be used in unconsolidated formations.
- The method is slower than other methods (average drilling progress is 30 to 50 feet per day).
- Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.
- The cost per hour or per foot of drilling may be substantially higher than other drilling methods.
- It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).

5.2.7 Cable Tool Drilling

A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.

When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added. When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).

Advantages of the cable-tool method include the following:

- Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.

- The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).

- When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.

- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.

Disadvantages include:

- Drilling is slow compared with rotary rigs.

- The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.

- The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).

- Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.

5.2.8 Jet Drilling (Washing)

Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.

Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.

Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:

- Jetting is fast and inexpensive.
- Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.
- Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.

Disadvantages include the following:

- A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.
- Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.
- The diameter of the casing is usually limited to 2 inches.
- Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).
- Large quantities of water are often needed.

5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers.
  - Retractable plug samplers--driven by hand (hammer).
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:

  - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (± 2-pound) hammer dropping 30 inches (± 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.

- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).

- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

5.7 Rock Sampling (Coring) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___|___/	1 7/8	1	1.875	1.000
BX Wire line ___|___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___|___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
PAGE TWO

Size Designations			Casing Coupling					Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings	Casing O.D., Inches	O.D., Inches	I.D., Inches	Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	—	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	—	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	—	5.500			5.650	—	—	—	—
SW	—	6.625			6.790	—	—	—	—
UW	—	7.625			7.800	—	—	—	—
ZW	—	8.625			8.810	—	—	—	—
—	AX __|__\	—	—	—	—	1.875	1.750	1.000	—
—	BX __|__\	—	—	—	—	2.345	2.250	1.437	—
—	NX __|__\	—	—	—	—	2.965	2.813	1.937	—

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.

___|___/ Wire line dimensions and designations may vary according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889

5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

6.0 REFERENCES

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	—
	7 1/4	6 1/4	3 1/4	—
	13 1/4	12	6	—
Thin Wall Tube Samplers (Ref. 7)	—	2	1 7/8	—
	—	2 1/2	2 3/8	—
	—	3	2 7/8	—
	—	3 1/2	3 3/8	—
	—	4 1/2	4 3/8	—
	—	5	4 3/4	—
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A
DRILLING EQUIPMENT SIZES
PAGE TWO

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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ATTACHMENTS

1.0 PURPOSE

This guideline is intended to describe procedures for performing in-situ hydraulic conductivity testing (slug testing) in boreholes and monitoring wells, and provide a short description of commonly used evaluation techniques for the data generated. Slug tests are used to provide data regarding the hydraulic properties of the formation tested. A variation of the slug test, called a constant-head test, is also briefly described.

2.0 SCOPE

Slug tests are short-term tests designed to provide approximate hydraulic conductivity values for the portion of a formation immediately surrounding the screened/open interval of a well or boring. These tests are much less accurate than pumping tests, as a much more localized area is involved. Therefore, a number of slug tests are typically performed and averaged to determine a representative hydraulic conductivity value for the formation tested. Performance of slug tests may be preferable to pumping tests in situations where handling of large volumes of contaminated water is a concern or when time/budget constraints preclude the more expensive and time-consuming setup and performance of a pumping test.

Constant-head tests also are used to determine hydraulic conductivity values and are similar to slug tests with regard to the quality of data obtained and time/cost considerations. A disadvantage of constant-head tests is that a significant volume of water may be added to high-permeability formations, potentially affecting short-term water quality.

3.0 GLOSSARY

Hydraulic Conductivity (K) - A quantitative measure of the ability of a porous material to transmit water, defined as the volume of water that will flow through a unit cross-sectional area of porous material per unit time under a head gradient of 1. Hydraulic conductivity is dependent upon properties of the medium and fluid. Common units of expression include centimeters per second (cm/sec), feet per day (ft/day), and gallons per day per foot^2 (gpd/ft^2).

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. The product of the hydraulic conductivity times the saturated thickness.

Slug Test - A rising head or falling head test used to measure hydraulic conductivity. A slug test consists of instantaneously changing the water level within a well and measuring the rate of recovery of the water level to equilibrium conditions. Slug tests are performed by either withdrawing a slug of water (rising head test) or adding a slug of water (falling head test), then measuring recovery over time. A solid slug of known volume can be used to displace a volume of water, thereby simulating the addition or removal of water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist, in conjunction with the Project Manager, shall evaluate the type(s) and extent of hydraulic testing required for a given project during the planning process, and design the field program accordingly. The project hydrogeologist also shall ensure that field personnel have the necessary training and guidance to properly perform the tests, and shall oversee data reduction activities, including selecting the appropriate evaluation techniques and checking calculations for accuracy.

Field Geologist - The field geologist is responsible for performing the planned field tests as specified in the project planning documents, (or approved modifications thereto). The field geologist also generally assists in the data evaluation process. The field geologist shall be knowledgeable in the testing methodologies used and is responsible for obtaining the necessary support equipment required to perform the field tests. All applicable data regarding testing procedures, equipment used, well construction, and geologic/hydrogeologic conditions shall be recorded by the field geologist. The field geologist shall be familiar enough with testing procedures/requirements to be able to recommend changes in methodology, should unanticipated field conditions be encountered.

5.0 PROCEDURES

5.1 In-situ Hydraulic Conductivity Testing in Wells

Slug tests are commonly performed in completed wells. Prior to testing, the well shall be thoroughly developed and allowed to stabilize, in order to obtain accurate results. Once the water level within the well has stabilized at its static level, it shall be quickly raised or lowered and the rate of recovery measured.

One of the basic assumptions of slug testing is that the initial change in water level is instantaneous; therefore, an effort shall be made to minimize the time involved in raising or lowering the water level initially. Various methods can be used to induce instantaneous (or nearly instantaneous) changes in water level within the well. A rise in water levels can be induced by pouring water into the well. A solid slug of known volume, quickly lowered below the water level within the well, will displace an equivalent volume of water and raise the water level within the well. The slug can be left in place until the water level restabilizes at the static water level, then suddenly removed to create a drop in water level within the well. An advantage of using a solid cylinder of known volume (slug) to change the water level is that no water is removed or added to the monitoring well. This eliminates the need to dispose of contaminated water and/or add water to the system. A bailer or pump can be used to withdraw water from the well. If a pump is used, pumping shall not continue for more than several seconds so that a cone of depression is not created which would adversely impact testing results. The pump hose shall also be removed from the well during the recovery period, as data analysis techniques involve volume of recovery versus time, and leaving the hose within the well would distort the calculated testing results by altering the apparent volume of recovery. Falling head slug tests should only be performed in wells with fully submerged screens, while rising head slug tests can be performed in wells with either partially or fully submerged screens/open intervals.

Other methods that can be used to change water levels within a well include creating a vacuum or a high pressure environment within the well. The vacuum method will raise water levels within the well, while the pressure method will depress the water level in the well. These methods are particularly useful in highly permeable formations where other methods are ineffective in creating measurable changes in water levels. Both of these methods are limited to wells which have completely submerged screens.

Rate of recovery measurements shall be obtained from time zero (maximum change in water level) until water level recovery exceeds 90 percent of the initial change in water level. In low permeability formations, the test may be cut-off short of 90 percent recovery due to time constraints. Time intervals between water level readings will vary according to the rate of recovery of the well. For a moderately fast recovering well, water level readings at 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 2.5, 3.0, 4.0, . . . minutes may be required. With practice, readings at down to 0.05-minute (3 seconds) time intervals can be obtained with reasonable accuracy, using a pressure transducer and hand held readout. For wells which recover very fast, a pressure transducer and data logger may be required to obtain representative data. Time intervals between measurements can be extended for slow recovering wells. A typical schedule for measurements for a slow recovering well would be 0, 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 15.0, 20.0, 30.0, . . . minutes from the beginning the test. Measurements shall be taken from the top of the well casing.

Water level measurements can be obtained using an electric water level indicator, popper, or pressure transducer. Steel tape coated with chalk or water sensitive paste although very accurate, is a slower method of obtaining water levels and is generally not recommended for use due to the frequency at which water level measurements need to be obtained during the performance of a slug test.

Time/recovery should be field-plotted on semilog graph paper to determine the data quality. The data set should plot along a sloped, straight line. If excessive data scatter is observed, the test should be rerun until acceptable results are obtained.

The following data shall be recorded when performing slug tests in wells or borings:

- Well/boring ID number
- Total depth of well/boring
- Screened/open interval depth and length
- Gravel pack interval depth and length
- Well stickup above ground surface
- Gravel pack radius
- Static water level
- Aquifer thickness
- Depth to confining layer
- Time/recovery data

A variation of the slug test, called a constant-head test, is a test in which water is added to the well at a measured rate sufficient to maintain the water level in the well at a constant height above the static water level. Once a stable elevated water level has been achieved, discharge (pumping) rate measurements are recorded in place of time/recovery data for approximately 10 to 20 minutes. The hydraulic conductivity is then calculated from this information. The constant-head test is generally not recommended for monitoring wells as large volumes of water may be introduced into the screened formation, potentially impacting later sampling events.

5.2 In-situ Hydraulic Conductivity Testing in Borings

Slug tests can be performed in borings while the boring is being advanced. This permits testing of formations at different depths throughout the drilling process. Boreholes to be tested shall be drilled using casing, so that discrete depths may be investigated. Various tests and testing methods are described below. The most appropriate test and testing method to be used in a situation varies and shall be selected after a careful evaluation of drilling, geologic, and general site conditions.

Rising head or falling head slug tests can be performed in saturated and unsaturated formations during drilling. There are two ways that the tests can be performed. One way entails setting the casing flush with the bottom of the boring when the desired testing depth has been reached. The hole is then cleaned out to remove loose materials, the drill bit and rods are carefully withdrawn from the boring, and a few feet of sand (of higher permeability than the surrounding formation) is added to the bottom of the boring. After the water level in the boring has stabilized (for saturated formations), the static water level is measured and recorded. The water level is then raised (falling head test) or lowered (rising head test) and the change in water level is measured at time intervals determined by the field hydrogeologist. Only falling head tests can be performed for depth intervals within the unsaturated (vadose) zone. As described for wells, time intervals for water level measurements will vary according to the formation's hydraulic conductivity. The faster the rate of recovery expected, the shorter the time intervals between measurements shall be. The rate of change of water level will be used to calculate hydraulic conductivity. The test is to be conducted until the water level again stabilizes, or for a minimum of 20 minutes. In low permeability formations, it is not always practical to run the test until the water level stabilizes, as it may take a long time to do so. The top of the casing shall be used as the reference point for all water level measurements.

The second method for conducting a slug test during drilling consists of placing a temporary well with a short screen into the cleaned-out boring, pulling the drilling casing back to expose the screen, allowing the formation to collapse around the screen (or placing a sand/gravel pack around the screen), and performing the appropriate hydraulic conductivity test in the well, as described for the first method. Again, the test shall be conducted until the water level stabilizes or for a minimum of 20 minutes. This method allows for testing a larger section of the formation and results in more reliable hydraulic conductivity estimates.

Constant-head tests may also be performed in borings. As described for monitoring wells, once a stable elevated level has been achieved, the discharge rate into the boring is measured for a period of time, usually 10 to 20 minutes, and the hydraulic conductivity is calculated from this. This method is the most accurate method depicted in this section, and shall be given preference over others if the materials are available to perform the test and the addition of water to the boring does not adversely impact project objectives. Once the test is over, additional information can be gathered by measuring the rate of the drop in water level in the boring (for saturated formations). A limitation of the constant-head test is that foreign water is introduced into the formation which must be removed from the well area by natural or artificial means, before a representative groundwater sample can be obtained.

Detailed descriptions regarding the performance of borehole hydraulic conductivity tests and subsequent data analysis techniques are provided in Ground Water Manual (1981).

5.3 Data Analysis

There are a number of data analysis methods available to reduce and evaluate slug testing data. The determination of which method is most appropriate shall be made based on the testing conditions (including physical setup of the well/boring tested, hydrogeologic conditions, and testing methodology) and the limitations of each test analysis method. Well construction details, aquifer type (confined or unconfined), and screened/open interval (fully or partially penetrating the aquifer) shall be taken into account in selecting an analysis method. Cooper, et al. (1967), and Papadapulos, et al. (1973) have developed test interpretation procedures for fully penetrating wells in confined aquifers. Hvorslev (1951) developed a relatively simple analytical procedure for point piezometers in an infinite isotropic medium. In Cedergren (1967), Hvorslev presents a number of analytical procedures which cover a wide variety of hydrogeologic conditions, testing procedures, and well/boring/piezometer configurations. Bouwer and Rice (1976) developed an analytical technique applicable to both unconfined and confined conditions, which factors in partial/full penetration and discusses well screen gravel pack considerations. The Ground Water Manual (1981) presents a number of testing and test analysis procedures for wells and borings open above or below the water table, and for both falling head and constant-head tests. The methods described above do not represent a complete listing of test analysis methods available, but are some of the more commonly used and accepted methods. Other methods can be used, at the discretion of the project hydrogeologist and in concurrence with the Project Manager and client.

One consideration to be noted during data analysis is the determination of the screened/open interval of a tested well. If a well with a fully submerged screen is installed in a relatively low permeability formation, and a gravel pack which is significantly more permeable is installed around the screen, the length of the gravel pack (if longer than the screened interval) should be used as the screened/open length, rather than the screen length itself. In situations where the formation permeability is judged to be comparable to the gravel pack permeability (within about an order of magnitude) this adjustment is not required.

All data analysis applications and calculations shall be reviewed by technical personnel thoroughly familiar with testing and test analysis procedures. Upon approval of the calculations and results, the calculation sheets shall be initialed and dated by the reviewer. Distribution copies shall be supplied to appropriate project personnel and the original copy stored in the project central file.

6.0 REFERENCES

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7.0 RECORDS

Field data shall be recorded on the data sheet included as Attachment A (or equivalent). 1 Any notes regarding testing procedures, problems encountered, and general observations not included on the data sheet shall be noted in the bound site logbook or field notebook. The boring log and well construction diagrams for each well/boring tested shall be used as references during testing and data analysis activities. Original data sheets shall be placed in the project file, along with the logbook/notebook.

1 If an automated data recorder is used, the data may be displayed using the printer output from the unit. Such printouts should be annoted to include the relevant data form, or attached to the form shown as Attachment A.

ATTACHMENT A
EXAMPLE HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

HYDRAULIC CONDUCTIVITY TESTING DATA SHEET

PROJECT NAME: .... WELL/BORING NO.: ....

PROJECT NO.: .... GEOLOGIST: ....

WELL DIAMETER: .... SCREEN LENGTH/DEPTH: .... TEST NO.: ....

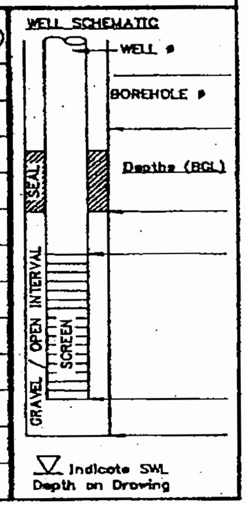
STATIC WATER LEVEL (Depth/Elevation): .... DATE: ....

TEST TYPE (Rising/Falling/Constant Head): .... CHECKED: ....

METHOD OF INDUCING WATER LEVEL CHANGE: .... PAGE ..... OF ....

REFERENCE PT. FOR WL MEAS. (Top of Casing, Transducer, etc.): ....

ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)	ELAPSED TIME (min. or sec.)	MEASURED WATER LEVEL (feet)	DRAWDOWN OR HEAD (ΔH) (feet)



REMARKS:
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CALCS, SKETCH MAPS, ETC.:

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1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Program Manager - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

Project Manager - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

Field Operations Leader - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and Sediment Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NNNN 4-Characters
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NN 2-Characters	-A
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

(3) Biota Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	AA 2-Characters	NNN 3-Characters
Site Identifier	Sample Type	Sample Location	Species Identifier	Sample Group Number

5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- Sampling Round Number
- Filtered
- Species Identifier
- Sample Group Number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to